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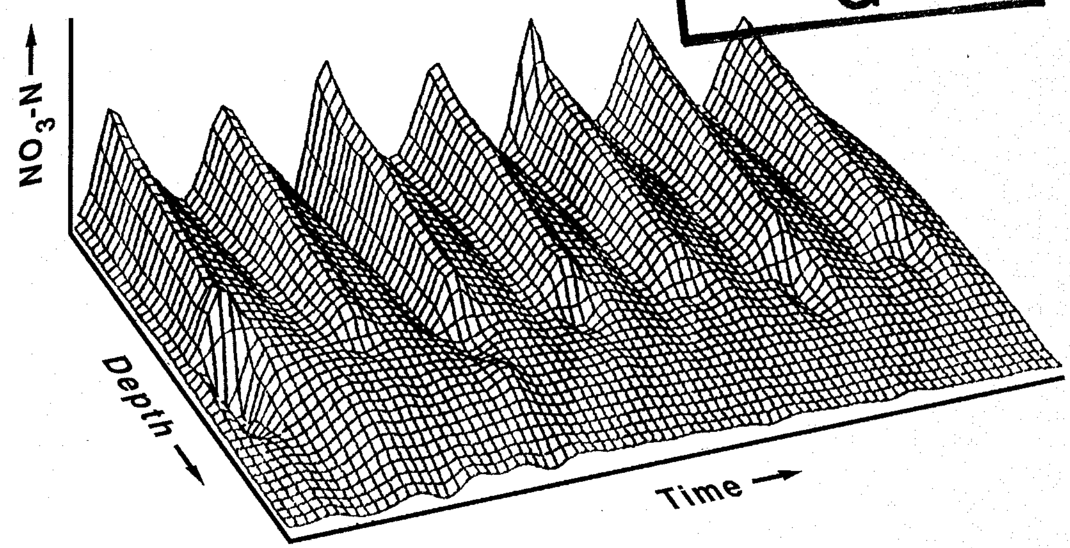
A Modeling-Based Evaluation of the Effect of Wastewater Application Practices on Groundwater Quality

Charles M. Reynolds and Iskandar K. Iskandar

February 1995



Abstract

The model WASTEN was used to compare several nitrogen input scenarios and to predict the levels of nitrate in groundwater for a proposed wastewater treatment facility at Fort Dix, New Jersey. The primary variables tested were input concentration of NO_3-N (nitrate nitrogen) and NH_4-N (ammonium nitrogen) and long-term application of wastewater. Two NO_3-N loading rates, 4 and 10 mg NO_3-N/L, were tested for 168-day simulations. The system's response was estimated from the NO_3-N concentration in water draining below 150 cm. For both input NO_3-N concentrations, the predicted NO_3-N concentrations in the leachate below 150 cm were less than 2 mg NO_3-N/L. The initial NO_3-N in the soil profile represented typical background levels for this site. The final NO_3-N in the soil profile was affected by both denitrification and leaching. The initial NH_4-N in the simulated soil profile was equal to the extractable NH_4-N from soil samples taken at the Fort Dix site. Because a portion of the extractable NH_4-N exists as exchangeable rather than solution NH_4-N, the soil profile values for the solution NH_4-N used in the simulation were greater than actual soil solution values would be. Moreover, by adjusting model coefficients, all the initial NH_4-N was forced to leach in the model simulations rather than be subjected to nitrification, denitrification, immobilization or plant uptake. Due to the retardation effects on NH_4-N mobility caused by soil-ion sorption, the NH_4-N leaching was distributed over an extended time rather than moving rapidly below the unsaturated zone. With these assumptions, the WASTEN model predicted that the NO_3-N at 150 cm would be less than 1 mg NO_3-N/L if the applied NO_3-N was 4 mg NO_3-N/L, and less than 2 mg NO_3-N/L if 10 mg NO_3-N/L was applied. The predicted concentration in the leachate was very low, even when an initial, uniform saturation of 5.0 mg NH_4-N/L in the soil profile was assumed. In field situations there would be little, if any, NO_4^+ present following tertiary treatment of wastewater. Based on these calculations, the predicted NO_4^+ concentration of NH_4-N in the applied effluent would remain within regulatory requirements.

Cover: Predicted soil nitrate distribution following pulsed wastewater application. The model output illustrates the combined effects of denitrification and nitrate transport.

For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380-89a, *Standard Practice for Use of the International System of Units,* published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

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Prepared for
OFFICE OF THE CHIEF OF ENGINEERS

PREFACE

This report was prepared by Dr. Charles M. Reynolds, Research Physical Scientist, and Dr. Iskandar K. Iskandar, Chief, Geochemical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). This work was initiated through the Numerical Model Maintenance Program, sponsored by HQUSACE #E8591S048. Major funding for the body of this work was provided by support from the U.S. Army Engineer District, Philadelphia, Project AT24-SS-020, *Chemical Species Transport Phenomena in Snow and Frozen Ground,* and Strategic Environmental Research and Development Program (SERDP), *Enhancing Bioremediation Processes in Cold Regions.*

The authors gratefully acknowledge the assistance of N. Hubler and P. Sitkowski, both of the U.S. Army Engineer District, Philadelphia; B. Neal, of Headquarters, Corps of Engineers; and Joe Roberto, CRREL, for administrative support. Appreciation is extended to Dr. Duane C. Wolf, University of Arkansas; Dr. Glen V. Wilson, University of Tennessee; Dr. H. Magdi Selim, Louisiana State University; and Susan E. Hardy, CRREL, for their thoughtful and critical reviews.

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A Modeling-Based Evaluation of the Effect of Wastewater Application Practices on Groundwater Quality

CHARLES M. REYNOLDS AND ISKANDAR K. ISKANDAR

INTRODUCTION

Wastewater treatment in soil by land application is a proven and effective technology that advantageously uses the natural ability of soil to degrade organic molecules on a long-term, regenerative basis. Because there are numerous interacting processes involved, mechanistic dynamic simulation models can provide insight into a system's response to a number of conditions. The model WASTEN was developed by Selim and Iskandar (1981) to predict nitrogen transport and transformations in soils receiving wastewater.

CRREL has assisted the Philadelphia District of the Corps of Engineers by providing technical consultation and WASTEN simulations for conditions appropriate for a proposed treatment facility at Fort Dix, New Jersey. We compared several nitrogen input scenarios and predicted the levels of nitrate in the groundwater for the proposed site.

Overview

In recent years the combined impacts of intentional and accidental releases of chemicals and waste solutions in and on soils, and our awareness of the vulnerability of groundwater to pollution from surface sources, have received increased attention. The rate of movement or transport of chemicals in soil and subsoils can vary tremendously, and consequently the time required for a solute to reach a given depth varies. Transport determines the residence time of a compound in each particular soil zone. During a chemical's residence in a soil zone, the chemical is subject to a host of biological, chemical and physical processes that combine to ultimately determine its fate. The governing processes are intimately linked to one another in myriad, complex chains of reactions and processes. Moreover, each process directly involved in altering a particular compound is, in turn, influenced by a multitude of other variables. Furthermore, the effects of these variables on different chemicals are not necessarily in the same magnitude or direction.

Many of the processes that occur are controlled by microbial, and thereby enzymatic, activity. The importance of microbial and enzymatic activities in transforming or degrading compounds containing energy or nutrient sources, such as nitrogen, carbon, phosphorus and sulfur, is reasonably intuitive. Nevertheless, physio-chemical processes, such as sorption–desorption and diffusion, are also important in determining the fate of compounds. Microbial or enzymatic processes can also influence compounds, such as metals, that are not used as nutrient or energy sources. In many instances, microbial-induced changes in microsite environments can induce fixation, immobilization or solvation of metals.

Bioremediation

The soil-mediated processes involved in the land treatment of wastewater are not new or unnatural. Microbes are known to adapt over time to transform or degrade compounds in their environment, and their enzymes can readily transform or completely degrade many non-anthropogenic organic compounds. Microbial enzyme systems may not be as efficient in transforming and breaking down more complex, anthropogenic molecules. However, there are enzymes that catalyze many of the reactions needed to degrade more recalcitrant, complex molecules. Often, a series of reactions must occur in a specific sequence to yield a desirable product. The conditions that favor any one of these processes may inhibit another pro-

cess, and the design and operation of a soil-based land treatment facility must consider these effects. Land treatment of wastewater is one of the earliest bioremediation techniques. The goal of the research preceding WASTEN was to understand how various soil conditions interact with processes, thereby enabling advantageous manipulation of soil conditions.

History

For early man, waste disposal was simple and without alternatives. In areas of sufficiently low population density, slight alterations of the earliest disposal methods may still suffice. However, as man became less nomadic and population centers developed, sanitation and health problems associated with ineffective waste disposal became more urgent. Land application to treat collected wastes and wastewater has been practiced for many years, and there are documented accounts of wastewater and sludge applications to soil during the 16th century (Wierzbicki 1977, Iskandar 1978). Pound and Crites (1975) cited currently operational systems in the United States that were started in approximately 1900.

Early practices of waste and wastewater application to soil were driven by the need to dispose of wastes. Although many soils have considerable natural capacity to treat wastes, little attention was given to operation or management. In the mid-1970s, research focused on identifying and understanding the controlling processes and their interactions. The inherent complexity of the overall process of soil-based remediation became increasingly apparent. Although useful empirical data could be obtained, the number of uncontrollable factors operating at any specific site or time made a strictly empirical approach intractable. To address these issues, modeling was incorporated into the research programs.

MODELING

Types

Many early models were primarily research oriented. Although model development and testing is still an active area for research, a number of design or management models have been spawned from earlier research programs. Management or operational models range from complex to fairly simple. Generally there is a compromise between the two extremes. More complex models require more input data and user knowledge and, being numerically complex, require more computer power and time to operate. Relatively simple models require less input data, less operator knowledge and less computing capabilities, but their output has less information about variations with soil depth. Safeguards are incorporated to prevent grossly erroneous output.

WASTEN

WASTEN is a dynamic simulation model developed at the Cold Regions Research and Engineering Laboratory by CRREL researchers and cooperating scientists (Selim and Iskandar 1981). Originally developed as a research tool, WASTEN incorporates a number of features not usually included in management-focused models. However, the increased capabilities and availability of computers has enabled the use of WASTEN for design, operation and management. In addition to the initial concentrations and distributions of NH_4-N (ammonium nitrogen) and NO_3-N (nitrate nitrogen) in the soil profile, wastewater application factors that can be input into WASTEN include the rate of application, the duration of application, the NH_4-N and NO_3-N concentrations and the wastewater application schedule or cycling. WASTEN can account for plant uptake, evapotranspiration, rainfall, soil layers and leaching. Nitrogen trans-

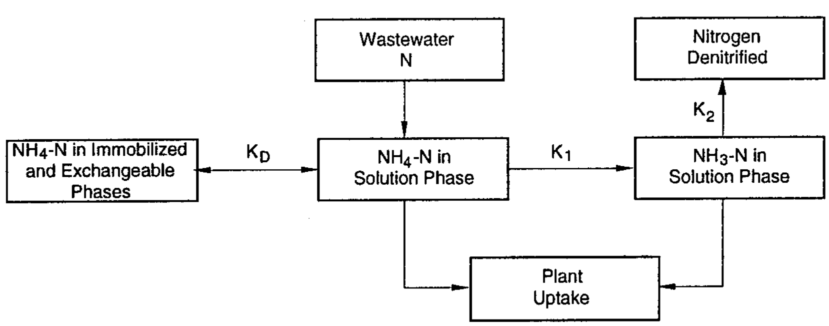


Figure 1. Nitrogen transformation processes considered in the nitrogen submodel. (After Selim and Iskandar 1981.)

formations addressed include nitrification of ammonium to nitrate, ammonium exchange on soil, and denitrification. Organic matter mineralization and immobilization are not specifically addressed by WASTEN, although control can be asserted through the nitrogen transformation rate constants. The relationships among these nitrogen forms and interacting processes are shown in Figure 1.

WASTEN includes a water transport submodel that is linked with a nitrogen submodel (Fig. 2). This linkage allows WASTEN to be used for steady-state and transient flow conditions, and it predicts water content and water flux throughout the soil profile and allows for upwards flow due to evapotranspiration.

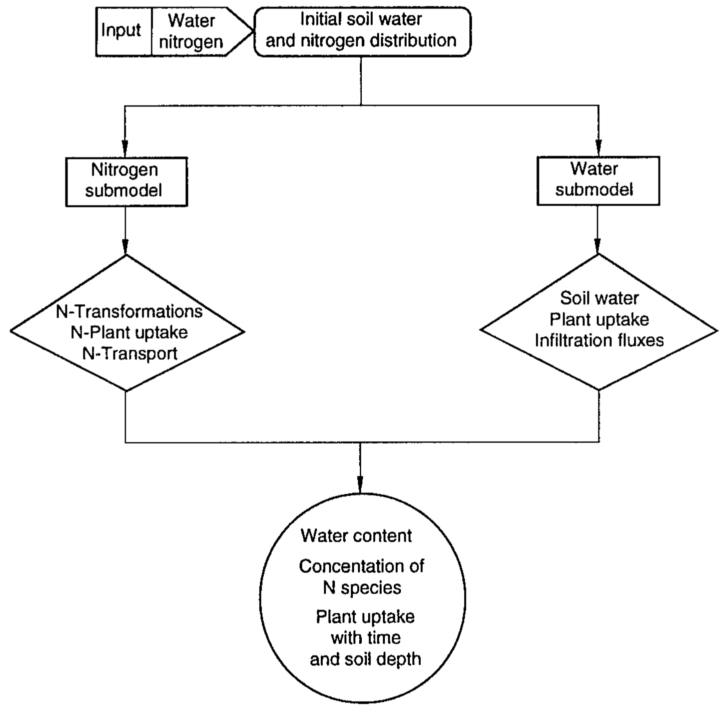


Figure 2. Simplified nitrogen model showing the water and nitrogen submodels. (After Selim and Iskandar 1980.)

The nitrogen submodel of WASTEN is built around the convective–dispersive transport equation, which couples the equation for continuity of mass with Fick's second law of diffusion. The resulting equation accounts for transport by diffusion, hydrodynamic dispersion and mass flow. For each nitrogen form treated by WASTEN, one analogous equation is developed (Fig. 3). Additionally, transformation processes are added onto each equation as source or sink terms. In use, WASTEN solves the resulting series of coupled equations by a modified, Crank–Nicolson, explicit–implicit finite-difference method. Integrated within the model is a water transport model that provides moisture content and flux at each node.

$$\frac{\partial C}{\partial t} = \underbrace{\underbrace{D\frac{\partial^2 C}{\partial z^2}}_{\text{Dispersion}} - \underbrace{V\frac{\partial C}{\partial z}}_{\text{Mass Flow}}}_{\text{Transport}} + \underbrace{\text{sources} - \text{sinks}}_{\text{Microbial Transformations}} - \text{plant uptake}$$

where D = *dispersion coefficient*

C = *concentration*

t = *time*

z = *depth*

V = *average pore water velocity*

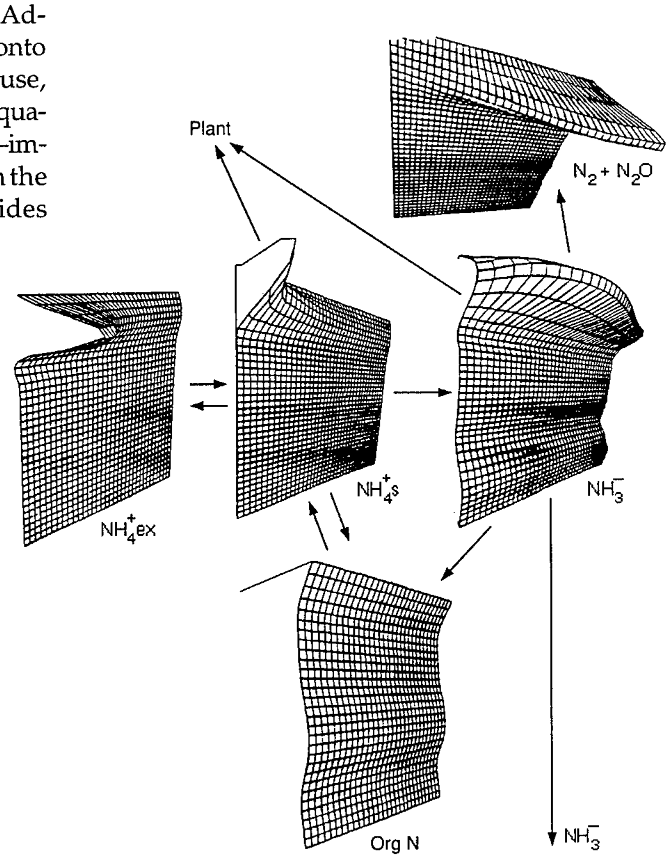


Figure 3. Interaction of nitrogen species and idealized model solution.

Validation

WASTEN has been extensively tested in both laboratory and field investigations. A listing of publications relating to WASTEN, its development and its testing is provided in Appendix A. WASTEN was recently used successfully and field-verified independently by researchers in Czechoslovakia to model the transport and transformation of nitrogen from fertilizer applications (Benes et al. 1989).

DENITRIFICATION

Introduction

A major component of WASTEN for wastewater treatment is denitrification—the microbial reduction of nitrate (NO_3^-) and nitrite (NO_2^-) to gaseous nitrogen (N) products, either as molecular N (N_2) or as oxides of N (NO, N_2O). Firestone (1982) depicted the overall pathway as:

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2 .$$

WASTEN uses first-order kinetics to describe the rate of denitrification. The reaction kinetics are also linked to soil aeration, expressed as and calculated from soil moisture content. In this way, for the denitrification component of the model to be active, both nitrate and aeration criteria must be met.

Firestone (1982) reported that approximately 23 genera of bacteria can perform denitrification and that almost all denitrifying bacteria are aerobic organisms capable of anaerobic growth only in the presence of nitrogen oxides. The important consequence is that for land treatment of wastewater, the microbes responsible for denitrification are able to survive in the alternating saturated and nonsaturated conditions to which the soil profile is subjected. For denitrification to occur, several criteria must be met: obviously an NO_3^- source must exist, oxidation conditions must be reduced, and a carbon (C) source must be available.

Carbon

Given necessary nitrate levels and anaerobic conditions, other factors influencing denitrification include available C, pH and temperature. Of these, C is frequently the limiting factor. It is well established that C levels are important in controlling denitrification, both as a source of cell material and as electron donors. The form of C is also important. In general, more-soluble C sources have a more rapid and greater effect than less-soluble C forms. Burford and Bremner (1975) observed positive correlations between denitrification and mineralizable C and also denitrification and water-soluble C. Stanford et al. (1975) found a positive correlation between denitrification and 0.01 M $CaCl_2$ extractable C. Because rhizosphere effects are generally thought to be caused by root excretions of C compounds, rhizosphere and root–soil interactions can also influence denitrification.

For soil systems that cycle between aerated and saturated conditions, C drives both the aerobic and the anaerobic processes. At the onset of saturation, dissolved O_2 in the soil solution creates aerobic conditions until the O_2 is depleted by microbial respiration. During respiration, O_2 consumption by microbial reduction requires C as an electron donor. As O_2 is depleted and soil atmosphere conditions become increasingly reduced, C oxidation will continue to occur, but NO_3^- serves as the electron acceptor. Consequently the cycling and denitrification of N is intimately linked with C metabolism.

Soil solution reaction

The effect of soil solution pH has been shown to influence denitrification activity (Firestone 1982). Denitrification has been observed in soils with a pH less than 5 (Gilliam and Gambrell 1978) and has even been observed in more acid soils of pH 3.5–4.0 (Klemmedtsson et al. 1978). It has been hypothesized that the effects of pH on denitrification may be related to interactions of pH and trace metal activity, especially molybdenum. Molybdenum is a necessary cofactor for nitrate reductase, a key enzyme in denitrification. There are numerous observations supporting denitrification over a wide pH range, and the most common influence is an increased proportion of N_2O produced as the pH decreases (Firestone 1982).

Temperature

Within limits, denitrification appears to follow the Arrhenius equation:

$$\ln v = (-\Delta H^*/RT) + C$$

where v = velocity
ΔH^* = activation energy
R = gas constant
T = temperature (K)
C = constant.

Although temperature affects the rate of chemical and biological processes, significant denitrifying activity has been found in soils at low tem-

peratures. Gamble et al. (1977) found that of 95 denitrifying isolates collected from diverse temperate soils, 65 were capable of growth and activity at 4°C, and 10 were capable of growth at 41°C. Most evidence indicates that, as a result of the diverse genera of bacteria involved, denitrifying organisms have adapted to a wide range of temperatures. Consequently, essentially all soils subjected to a range of temperatures demonstrate denitrification activity over that range.

METHODS

CRREL assisted the Philadelphia District of the Corps of Engineers by providing WASTEN simulations for conditions appropriate for a proposed treatment facility at Fort Dix. Both short-term and long-term steady-state simulations were run.

Initial short-term simulations

Input

The initial WASTEN simulations were based on conservative input data estimates, representing worse-than-expected conditions:

- The soil depth from the surface to the water table was set at 150 cm (4 ft).
- The soil was assumed to have three layers within the profile.
- The soil-water characteristics for the simulation were described using an equation developed by Green and Corey (1971), and the coefficients used were from Windsor sandy loam soil, B horizon, which has physical properties similar to the soil at the Fort Dix site.
- The plant uptake and evapotranspiration were set to zero.
- The loading rate for nitrogen was based on 4 mg NO_3-N/L in wastewater and approximately 21 cm of wastewater applied per cycle. This application was determined from the 5.6 million gallons/day (mgd) on a 25-acre surface.
- The initial conditions for the soil profile were (a) saturation throughout to provide maximal NO_3-N transport rates, and (b) negligible NO_3-N and NH_4-N concentrations.
- Denitrification was based on first-order kinetics and moisture content. The relatively conservative denitrification rate used was 0.01 hr^{-1}. Since no NH_x-N was applied, nitrification rates are not active in this simulation.
- The depth (cm) of wastewater applied and the concentration (mg/L) of NH_4-N and NO_3-N are listed for each simulation cycle.

The output obtained from the model included:

- The predicted NO_3-N concentrations for the entire profile to a depth of 150 cm at 2-cm increments;
- The amount of groundwater outflow during the cycle (cm); and
- The amount of NO_3-N leached below the unsaturated zone.

The concentration of N entering groundwater from the soil profile can be calculated from the water outflow and the amount of NO_3-N leached. Since the model output uses a 1000-cm^2 area, the mean concentration of N in water entering the saturated zone is:

$$\frac{\text{total N leached (mg N)}\left(1000\text{cm}^3\right)}{\text{total water outflow (cm)} \times \text{area}\left(1000\text{cm}^2\right) \times \text{L}} = \frac{\text{mg N}}{\text{L}} .$$

Results

Initially two simulations were run. Simulation 1 (App. B) represented 21 cm of 4 mg NO_3-N/L applied once, with the output listed every day for four days following application. The mean concentration of the output N was 0.97 mg N/L, which included and was "diluted" with the water initially in the profile. At day 4 the NO_3-N "bulge" is at approximately 35 cm. Also, the average total output, about 0.097 mg N/L, is less than the initial N concentration in the profile (0.1 mg N/L). That is, the leading edge of the incoming wastewater is being denitrified sufficiently so that it dilutes the already low N concentrations in the profile.

Simulation 2 (App. C) represented 21 cm of 4 mg NO_3-N/L water applied daily for four consecutive days, with the output given daily. This simulates repeated applications of all the wastewater on half the total acreage. Following the fourth day of N application, the output was continued for several more days of leaching. The final output estimated the NO_3-N concentrations in the lower profile to be 1.105 mg N/L, and the mean cumulative N concentration entering the groundwater was predicted to be 1.6 mg N/L.

Long-term steady-state simulations

Input

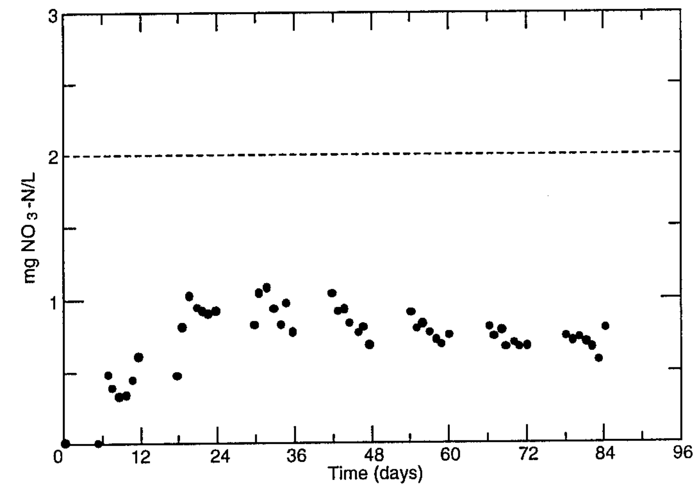
Based on the results of the first two simulations, further model simulations were conducted to provide insight into longer-term effects of land treat-

ment on the projected soil profile efflux NO_3-N concentration levels at the site. Additionally, the wastewater dosages were changed to more accurately reflect those intended for the site. The simulations were continued until the long-term trend of the NO_3-N outflow was discernible. The input data more accurately represented the proposed soil renovation treatment for wastewater:

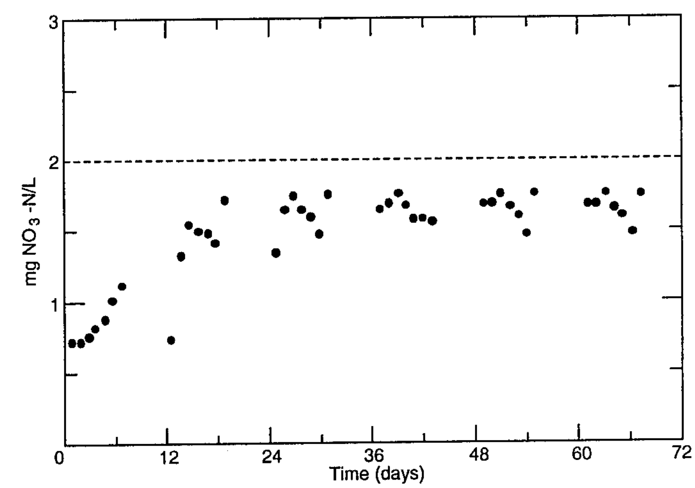
- The loading rates for nitrogen were based on either 4 or 10 mg NO_3-N/L in wastewater and approximately 104 cm of wastewater applied per cycle. These two N concentrations were used to represent the design- and worst-case N levels in the effluent. (Earlier simulations used 4 mg NO_3-N/L at a depth of 21 cm.)
- The application volume (ponding depth) was determined from a loading rate of 4.6 million gallons/day for two consecutive days, on an 8-acre surface (two cells, each having an area of 4 acres). The application was followed by a 10-day rest.
- From the data provided by the Philadelphia District of the Corps of Engineers, an initial concentration of 0.5 mg NO_3-N/L was assumed in the entire soil profile.
- The simulations were conducted for seven 12-day cycles with 104 cm of 4 mg NO_3-N/L applied each cycle, and also five 12-day cycles with 104 cm of 10-mg NO_3-N/L wastewater applied each cycle.
- Additionally the two simulations were run sequentially, with applications of 4 mg NO_3-N/L followed by a series of applications of 10 mg NO_3-N/L.
- The initial ammoniacal N was assumed to be 5.0 mg/L NH_x-N, based on data provided by the Philadelphia District of the Corps of Engineers.

The following input data and assumptions were the same as those used for the earlier simulations. As stated before, these are conservative assumptions and estimates, representing worse-than-expected conditions.

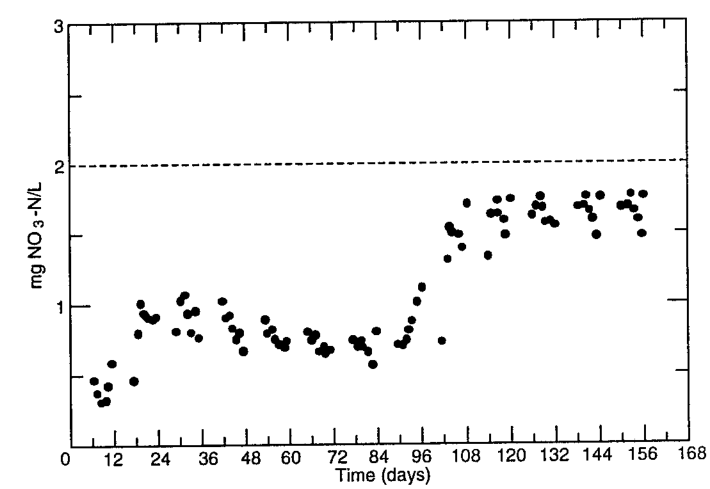
- The soil depth to the water table was set at 150 cm (4.9 ft), which is conservative. Temporary water table mounding during infiltration could conceivably raise the water table significantly for short periods. This effect would most likely increase denitrification by reducing the av-



a. 4 mg NO_3-N/L applied.



b. 10 mg NO_3-N/L applied.



c. Days 1–89, 4 mg NO_3-N/L in wastewater; days 90–156, 10 mg NO_3-N/L in wastewater.

Figure 4. NO_3-N efflux from the soil profile during wastewater application (12-day cycles).

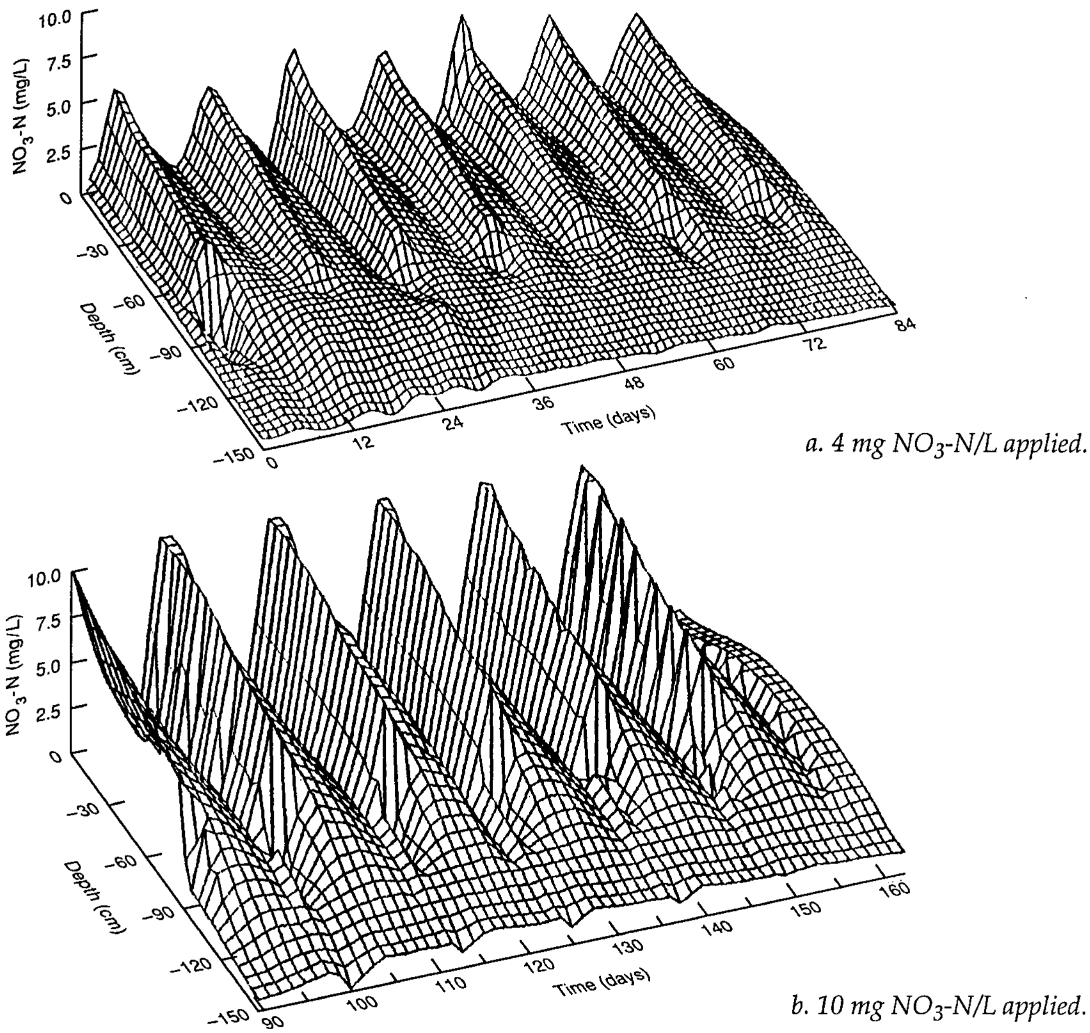


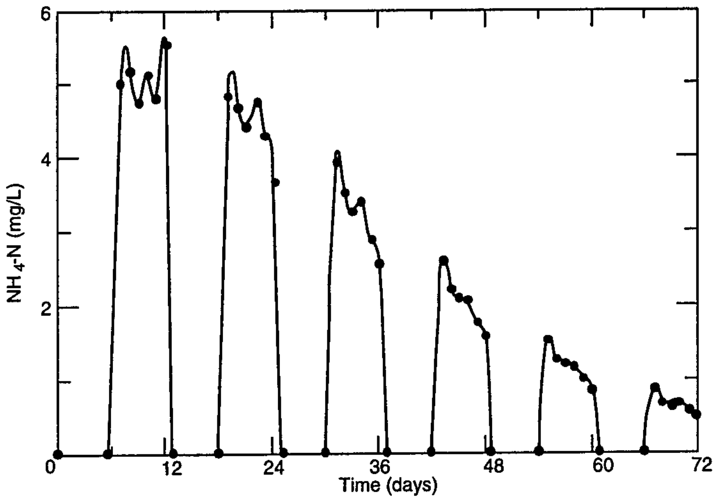
Figure 5. NO_3-N in the soil profile.

erage velocity of water movement. Moreover, denitrification would be promoted by saturated conditions.

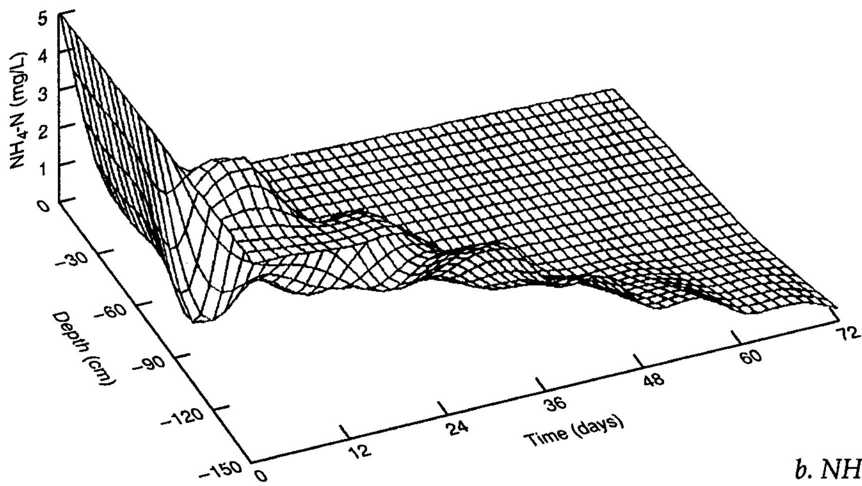
- The soil was assumed to have three layers within the profile.
- The soil-water characteristics for the simulation were described using an equation developed by Green and Corey (1971) and using coefficients from Windsor sandy loam soil, B horizon, which is similar to the soil at the Fort Dix site.
- The plant uptake and evapotranspiration were set to zero. Ultimately these two processes will tend to reduce N levels in the soil, either by direct uptake or by increasing the conditions that promote denitrification. Setting coefficients for evapotranspiration and plant uptake of N forces the model to assume that N not lost by denitrification will be lost as NO_3-N leachate.
- Denitrification was based on first-order kinetics and moisture content. The relatively conservative denitrification rate used was 0.01 hr^{-1}.

Results

Figures 4–7 show the output from these simulations. The concentration values for the output were derived using the same technique as used in the short-term simulations. The WASTEN model simulations indicated that, under the conditions used for the computer simulations, the NO_3-N concentrations in the soil solution leaving the upper 150 cm of the soil profile would not exceed 2.0 mg/L. This was true for both application rates: 4.0 and 10.0 mg/L NO_3-N in the wastewater (Fig. 4a and b). Additionally, NO_3-N output following 168 days of treatment (seven cycles each of 4.0 and 10.0 mg/L NO_3-N in the wastewater) showed NO_3-N efflux below 2 mg/L NO_3-N (Fig. 4c).



a. NH_4-N efflux from the soil profile.



b. NH_4-N distribution in the soil profile.

Figure 6. NH_4-N assuming a uniform initial concentration of 5 mg NH_4-N/L and no transformations.

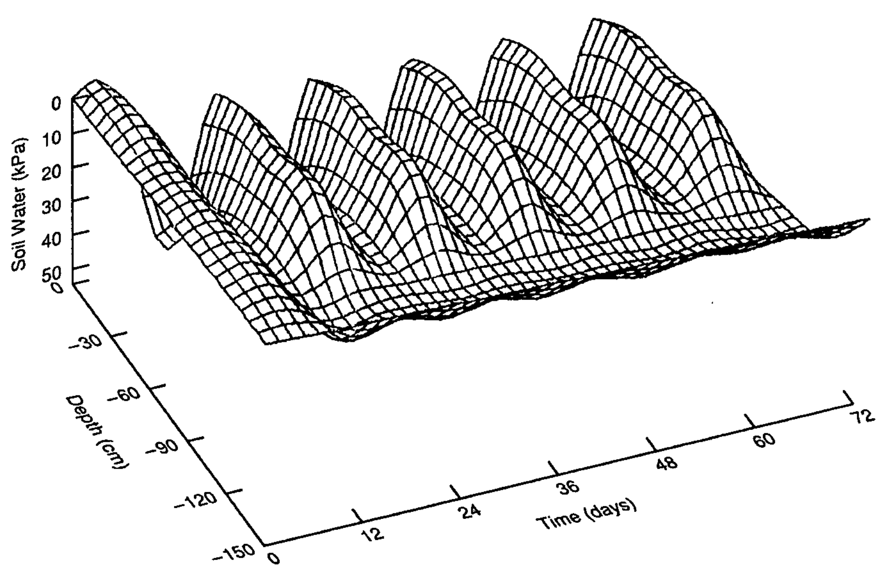


Figure 7. Soil-water potential distribution. Zero kPa indicates complete pore-space saturation.

The profile distributions of NO_3-N for both 4 and 10 mg/L NO_3-N exhibited high initial concentrations of NO_3-N, essentially equivalent to that in the applied wastewater, in the upper profile (Fig. 5). During the cycle, NO_3-N levels decreased as denitrification proceeded.

A high, uniform initial ammoniacal-N concentration of 5.0 mg/L NH_x-N in the soil profile was also tested to demonstrate the release of NH_4-N from the 150-cm profile. For this simulation the nitrification coefficient was set to zero, thereby forcing all NH_4-N to leach. After an initial release the NH_4-N had relatively insignificant effects on N concentrations in the leachate (Fig. 6a). Due to cation exchange processes between the soil and NH_4-N cations, movement of NH_4-N is slow in the soil profile (Fig. 6b). Even starting with a high, uniform distribution and setting model parameters to allow leaching as the only loss pathway, as was done in the simulation, N contributions to the leachate were diffused over an extended time and therefore made relatively minor contributions to leachate N levels.

Soil-water potential

Soil-water potential, expressed in tension values, are shown in Figure 7. At lower soil depths the soil remains essentially saturated. In the upper soil profile, above approximately 75 cm, the soil cycles between saturated and unsaturated conditions. It is the cycling conditions in the vadose zone that allow both aerobic and anaerobic processes to readily occur.

RECOMMENDATIONS

Wastewater treatment in soil by land application is a proven and effective technology. In addition to cost benefits, soil has a natural ability to recover from a wide variety of stresses it may encounter. Denitrification, the major microbial process for reducing NO_3-N, is well documented and occurs in virtually all soils under appropriate conditions.

Because denitrification is driven by microbial processes, it is carbon dependent. Eliminating all carbon from the applied wastewater could inhibit denitrification. Hence, excessive removal of all organics from the wastewater could be detrimental for nitrogen treatment. The alternating wet–dry, aerobic–anaerobic conditions that will occur in the vadose zone should provide for a wide range of microbial processes to occur that will promote the metabolism of added organic material.

Like all dynamic simulation models that describe a series of complex, interrelated processes, WASTEN estimates the impacts that might result from changing input variables. The results from model simulations provide insight into the trends and direction of potential outcomes resulting from changing conditions. The model output is a legitimate means to express magnitude and direction, but it does not necessarily represent the exact values that will be measured in the field. This concept can be appreciated by considering the difficulty in accurately measuring existing properties and concentrations in field samples. Nevertheless the validity and utility of using models to estimate the impact of different design and operation options is well accepted.

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APPENDIX A: PUBLICATIONS RELATING TO WASTEN, ITS DEVELOPMENT AND ITS TESTING

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APPENDIX B: RESULTS OF SIMULATION 1.

```
*******************************************************************************
*  Initial simulation number 1                                                *
*  SUMMARY INPUT                                                              *
*  21 CM Wastewater, 4 mg/L NO3-N, applied one time, output listed for 4 days. *
*******************************************************************************
                  I N P U T   D A T A


 INITIAL DT, HR =    .01000
 INITIAL DZ , CM=   1.00000


 TOTAL LENGTH OF SOIL PROFILE, CM = 150.00000
 SOIL DEPTH TO THE FIRST SOIL LAYER, CM =  15.00000
 SOIL DEPTH TO THE SECOND SOIL LAYER, CM =  45.00000

 SOIL WATER PARAMETERS FOR THE FIRST  LAYER :      .9600E-05      .2763E+02      .1000E+03      .1000E+01
 SOIL WATER PARAMETERS FOR THE SECOND LAYER :      .2200E-05      .3070E+02      .4000E+02      .1000E+01
 SOIL WATER PARAMETERS FOR THE THIRD  LAYER :      .2100E-05      .3887E+02      .3000E+02      .1000E+01
 FIRST LAYER  ;  BULK DENSITY =   1.60000          SATURATION =   .44000
 SECOND LAYER ;  BULK DENSITY =   1.60000          SATURATION =   .42000
 THIRD  LAYER ;  BULK DENSITY =   1.60000          SATURATION =   .34000

 FIRST LAYER:          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                      NITRIFICATION RATE COEF.,HR-1 =    .10000
                      DENITRIFICATION RATE COEF., HR-1 =    .01000
 SECOND LAYER          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                      NITRIFICATION RATE COEF.,HR-1 =    .10000
                      DENITRIFICATION RATE COEF., HR-1 =    .01000
 THIRD LAYER:          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                      NITRIFICATION RATE COEF.,HR-1 =    .10000
                      DENITRIFICATION RATE COEF., HR-1 =    .01000

 SOLUTE DISPERSION COEFFICIENT, CM**2/HR =   2.50000

 MICHAELIS CONSTANT, MG/LITRE  =   1.00000

 INITIAL DISTRIBUTION OF PRESSURE HEAD,CM
 .000    .000    .000    .000
 AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  40.000  75.000 150.000
 INITIAL DISTRIBUTION OF NH4-N,MG/ML IN SOL
 .010    .010    .010    .010    .010    .010
 AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  15.000  30.500  48.000  98.000 150.000
 INITIAL DISTRIBUTION OF NO3-N,MG/ML IN SOL
 .100    .100    .100    .100    .100    .100
 AT THE CORRESPONDING SOIL DEPTHS OF, CM
7.500  15.000  30.500  48.000  98.000 150.000
                        TOTAL ELAPSED TIME  =       .00  DAYS
```

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	.00	.44	.0000	.010	.100
2.00	.00	.44	.0042	.010	.100
4.00	.00	.44	.0042	.010	.100
6.00	.00	.44	.0042	.010	.100
8.00	.00	.44	.0042	.010	.100
10.00	.00	.44	.0042	.010	.100
12.00	.00	.44	.0042	.010	.100
14.00	.00	.44	.0042	.010	.100
16.00	.00	.42	1.8284	.010	.100
18.00	.00	.42	.0014	.010	.100
20.00	.00	.42	.0014	.010	.100
22.00	.00	.42	.0014	.010	.100
24.00	.00	.42	.0014	.010	.100
26.00	.00	.42	.0014	.010	.100
28.00	.00	.42	.0014	.010	.100
30.00	.00	.42	.0014	.010	.100
32.00	.00	.42	.0014	.010	.100
34.00	.00	.42	.0014	.010	.100

36.00	.00	.42	.0014	.010	.100
38.00	.00	.42	.0014	.010	.100
40.00	.00	.42	.0014	.010	.100
42.00	.00	.42	.0014	.010	.100
44.00	.00	.42	.0014	.010	.100
46.00	.00	.34	.8754	.010	.100
48.00	.00	.34	.0016	.010	.100
50.00	.00	.34	.0016	.010	.100
52.00	.00	.34	.0016	.010	.100
54.00	.00	.34	.0016	.010	.100
56.00	.00	.34	.0016	.010	.100
58.00	.00	.34	.0016	.010	.100
60.00	.00	.34	.0016	.010	.100
62.00	.00	.34	.0016	.010	.100
64.00	.00	.34	.0016	.010	.100
66.00	.00	.34	.0016	.010	.100
68.00	.00	.34	.0016	.010	.100
70.00	.00	.34	.0016	.010	.100
72.00	.00	.34	.0016	.010	.100
74.00	.00	.34	.0016	.010	.100
76.00	.00	.34	.0016	.010	.100
78.00	.00	.34	.0016	.010	.100
80.00	.00	.34	.0016	.010	.100
82.00	.00	.34	.0016	.010	.100
84.00	.00	.34	.0016	.010	.100
86.00	.00	.34	.0016	.010	.100
88.00	.00	.34	.0016	.010	.100
90.00	.00	.34	.0016	.010	.100
92.00	.00	.34	.0016	.010	.100
94.00	.00	.34	.0016	.010	.100
96.00	.00	.34	.0016	.010	.100
98.00	.00	.34	.0016	.010	.100
100.00	.00	.34	.0016	.010	.100
102.00	.00	.34	.0016	.010	.100
104.00	.00	.34	.0016	.010	.100
106.00	.00	.34	.0016	.010	.100
108.00	.00	.34	.0016	.010	.100
110.00	.00	.34	.0016	.010	.100
112.00	.00	.34	.0016	.010	.100
114.00	.00	.34	.0016	.010	.100
116.00	.00	.34	.0016	.010	.100
118.00	.00	.34	.0016	.010	.100
120.00	.00	.34	.0016	.010	.100
122.00	.00	.34	.0016	.010	.100
124.00	.00	.34	.0016	.010	.100
126.00	.00	.34	.0016	.010	.100
128.00	.00	.34	.0016	.010	.100
130.00	.00	.34	.0016	.010	.100
132.00	.00	.34	.0016	.010	.100
134.00	.00	.34	.0016	.010	.100
136.00	.00	.34	.0016	.010	.100
138.00	.00	.34	.0016	.010	.100
140.00	.00	.34	.0016	.010	.100
142.00	.00	.34	.0016	.010	.100
144.00	.00	.34	.0016	.010	.100
146.00	.00	.34	.0016	.010	.100
148.00	.00	.34	.0016	.010	.100
150.00	.00	.34	.0016	.010	.100

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 5.490

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .549

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .600

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = 1.149

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = .00000

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUNULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

THIS IS CYCLE NUMBER = 1

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 4.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 1.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-4.84	.42	.8750	.000	3.989
2.00	-4.50	.42	.8829	.000	3.951
4.00	-4.09	.42	.8829	.000	3.914
6.00	-3.61	.42	.8829	.000	3.876
8.00	-3.04	.43	.8829	.000	3.839
10.00	-2.37	.43	.8829	.000	3.802
12.00	-1.59	.43	.8829	.000	3.765
14.00	-.70	.44	.8829	.000	3.728
16.00	.08	.42	.8829	.000	3.693
18.00	.07	.42	.8829	.000	3.658
20.00	.07	.42	.8829	.002	3.623
22.00	.05	.42	.8829	.003	3.588
24.00	.04	.42	.8829	.004	3.553
26.00	.03	.42	.8829	.005	3.517
28.00	.01	.42	.8829	.006	3.478
30.00	-.00	.42	.8829	.008	3.434
32.00	-.02	.42	.8829	.008	3.381
34.00	-.06	.42	.8829	.009	3.315
36.00	-.11	.42	.8829	.009	3.228
38.00	-.18	.42	.8829	.010	3.114
40.00	-.30	.42	.8829	.010	2.966
42.00	-.48	.42	.8829	.010	2.780
44.00	-.76	.42	.8829	.010	2.558
46.00	-.90	.34	.8829	.010	2.342
48.00	-.90	.34	.8829	.010	2.116
50.00	-.90	.34	.8829	.010	1.875
52.00	-.90	.34	.8829	.010	1.627
54.00	-.90	.34	.8829	.010	1.379
56.00	-.90	.34	.8829	.010	1.141
58.00	-.90	.34	.8829	.010	.922
60.00	-.90	.34	.8829	.010	.728
62.00	-.90	.34	.8829	.010	.562
64.00	-.89	.34	.8829	.010	.427
66.00	-.88	.34	.8829	.010	.321
68.00	-.87	.34	.8829	.010	.241
70.00	-.84	.34	.8829	.010	.184
72.00	-.79	.34	.8829	.010	.144
74.00	-.71	.34	.8829	.010	.118
76.00	-.58	.34	.8829	.010	.102
78.00	-.36	.34	.8829	.010	.093
80.00	.00	.34	.8829	.010	.090
82.00	.00	.34	1.1528	.010	.100
84.00	.00	.34	.0016	.010	.100

86.00	.00	.34	.0016	.010	.100
88.00	.00	.34	.0016	.010	.100
90.00	.00	.34	.0016	.010	.100
92.00	.00	.34	.0016	.010	.100
94.00	.00	.34	.0016	.010	.100
96.00	.00	.34	.0016	.010	.100
98.00	.00	.34	.0016	.010	.100
100.00	.00	.34	.0016	.010	.100
102.00	.00	.34	.0016	.010	.100
104.00	.00	.34	.0016	.010	.100
106.00	.00	.34	.0016	.010	.100
108.00	.00	.34	.0016	.010	.100
110.00	.00	.34	.0016	.010	.100
112.00	.00	.34	.0016	.010	.100
114.00	.00	.34	.0016	.010	.100
116.00	.00	.34	.0016	.010	.100
118.00	.00	.34	.0016	.010	.100
120.00	.00	.34	.0016	.010	.100
122.00	.00	.34	.0016	.010	.100
124.00	.00	.34	.0016	.010	.100
126.00	.00	.34	.0016	.010	.100
128.00	.00	.34	.0016	.010	.100
130.00	.00	.34	.0016	.010	.100
132.00	.00	.34	.0016	.010	.100
134.00	.00	.34	.0016	.010	.100
136.00	.00	.34	.0016	.010	.100
138.00	.00	.34	.0016	.010	.100
140.00	.00	.34	.0016	.010	.100
142.00	.00	.34	.0016	.010	.100
144.00	.00	.34	.0016	.010	.100
146.00	.00	.34	.0016	.010	.100
148.00	.00	.34	.0016	.010	.100
150.00	.00	.34	.0016	.010	.100

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 78.575

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .436

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .497

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .933

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 9.94938

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

TOTAL ELAPSED TIME = 2.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-38.36	.32	.0000	.000	3.151
2.00	-36.41	.32	.0017	.000	3.151
4.00	-34.48	.33	.0024	.000	3.164
6.00	-32.58	.33	.0039	.000	3.184
8.00	-30.70	.34	.0055	.000	3.207
10.00	-28.84	.34	.0071	.000	3.231
12.00	-26.98	.35	.0088	.000	3.256
14.00	-25.12	.35	.0104	.000	3.279
16.00	-23.34	.34	.0122	.000	3.288
18.00	-22.60	.34	.0143	.001	3.269
20.00	-21.93	.34	.0164	.002	3.233

22.00	-21.31	.34	.0186	.002	3.187
24.00	-20.73	.35	.0207	.003	3.135
26.00	-20.18	.35	.0227	.004	3.081
28.00	-19.66	.35	.0248	.005	3.025
30.00	-19.15	.35	.0268	.005	2.967
32.00	-18.65	.35	.0287	.006	2.908
34.00	-18.14	.35	.0306	.007	2.848
36.00	-17.62	.36	.0325	.007	2.785
38.00	-17.08	.36	.0343	.008	2.719
40.00	-16.49	.36	.0361	.009	2.651
42.00	-15.86	.36	.0378	.009	2.582
44.00	-15.16	.37	.0394	.009	2.513
46.00	-13.81	.28	.0409	.009	2.450
48.00	-13.62	.28	.0426	.010	2.379
50.00	-13.44	.28	.0443	.010	2.296
52.00	-13.26	.28	.0460	.010	2.199
54.00	-13.10	.29	.0477	.010	2.092
56.00	-12.94	.29	.0494	.010	1.976
58.00	-12.78	.29	.0510	.010	1.851
60.00	-12.64	.29	.0527	.010	1.721
62.00	-12.49	.29	.0544	.010	1.587
64.00	-12.35	.29	.0560	.010	1.451
66.00	-12.22	.29	.0576	.010	1.314
68.00	-12.09	.29	.0593	.010	1.180
70.00	-11.97	.29	.0609	.010	1.050
72.00	-11.85	.29	.0625	.010	.925
74.00	-11.73	.29	.0641	.010	.808
76.00	-11.61	.29	.0657	.010	.699
78.00	-11.50	.29	.0673	.010	.599
80.00	-11.39	.29	.0689	.010	.510
82.00	-11.29	.29	.0705	.010	.431
84.00	-11.19	.29	.0720	.010	.362
86.00	-11.09	.29	.0736	.010	.303
88.00	-10.99	.29	.0752	.010	.253
90.00	-10.90	.29	.0767	.010	.213
92.00	-10.80	.29	.0783	.010	.180
94.00	-10.71	.30	.0798	.010	.153
96.00	-10.63	.30	.0814	.010	.133
98.00	-10.54	.30	.0829	.010	.117
100.00	-10.45	.30	.0844	.010	.106
102.00	-10.37	.30	.0860	.010	.097
104.00	-10.29	.30	.0875	.010	.091
106.00	-10.21	.30	.0890	.010	.087
108.00	-10.13	.30	.0905	.010	.084
110.00	-10.05	.30	.0920	.010	.082
112.00	-9.98	.30	.0935	.010	.081
114.00	-9.90	.30	.0950	.010	.080
116.00	-9.82	.30	.0965	.010	.080
118.00	-9.74	.30	.0980	.010	.080
120.00	-9.66	.30	.0995	.010	.079
122.00	-9.57	.30	.1010	.010	.079
124.00	-9.47	.30	.1024	.010	.079
126.00	-9.35	.30	.1038	.010	.079
128.00	-9.21	.30	.1052	.010	.079
130.00	-9.04	.30	.1066	.010	.079
132.00	-8.81	.30	.1079	.010	.079
134.00	-8.50	.30	.1092	.010	.079
136.00	-8.08	.31	.1103	.010	.079
138.00	-7.53	.31	.1114	.010	.079
140.00	-6.79	.31	.1123	.010	.079
142.00	-5.85	.32	.1130	.010	.079
144.00	-4.69	.32	.1136	.010	.079
146.00	-3.30	.33	.1139	.010	.079
148.00	-1.73	.33	.1142	.010	.079
150.00	.00	.34	.1143	.010	.079

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 65.152

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .368
TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .483

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .851

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 22.61943

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.33980

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .14514

CUMULATIVE WATER OUTFLOW , CM = 14.51430

TOTAL ELAPSED TIME = 3.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-42.62	.31	.0000	.000	2.413
2.00	-40.86	.31	.0079	.000	2.373
4.00	-39.02	.32	.0045	.000	2.390
6.00	-37.18	.32	.0051	.000	2.419
8.00	-35.34	.33	.0056	.000	2.454
10.00	-33.50	.33	.0062	.000	2.495
12.00	-31.64	.33	.0068	.000	2.536
14.00	-29.79	.34	.0074	.000	2.577
16.00	-27.99	.32	.0081	.001	2.615
18.00	-27.30	.32	.0090	.002	2.646
20.00	-26.64	.32	.0099	.002	2.671
22.00	-26.01	.33	.0109	.003	2.691
24.00	-25.39	.33	.0119	.003	2.704
26.00	-24.79	.33	.0129	.004	2.713
28.00	-24.21	.33	.0140	.004	2.717
30.00	-23.62	.34	.0150	.005	2.714
32.00	-23.03	.34	.0160	.005	2.706
34.00	-22.42	.34	.0171	.006	2.667
36.00	-21.78	.34	.0181	.006	2.612
38.00	-21.11	.34	.0190	.007	2.547
40.00	-20.38	.35	.0200	.008	2.476
42.00	-19.60	.35	.0209	.008	2.404
44.00	-18.74	.35	.0218	.008	2.333
46.00	-17.27	.27	.0226	.009	2.270
48.00	-17.06	.27	.0236	.009	2.213
50.00	-16.86	.27	.0246	.009	2.153
52.00	-16.67	.27	.0256	.009	2.088
54.00	-16.49	.27	.0265	.009	2.017
56.00	-16.31	.27	.0275	.010	1.943
58.00	-16.14	.27	.0284	.010	1.856
60.00	-15.98	.27	.0294	.010	1.760
62.00	-15.82	.27	.0303	.010	1.658
64.00	-15.66	.27	.0313	.010	1.553
66.00	-15.52	.28	.0322	.010	1.445
68.00	-15.37	.28	.0331	.010	1.338
70.00	-15.23	.28	.0341	.010	1.230
72.00	-15.10	.28	.0350	.010	1.125
74.00	-14.97	.28	.0359	.010	1.023
76.00	-14.84	.28	.0368	.010	.924
78.00	-14.72	.28	.0377	.010	.830
80.00	-14.60	.28	.0386	.010	.741
82.00	-14.48	.28	.0396	.010	.658
84.00	-14.37	.28	.0405	.010	.581
86.00	-14.26	.28	.0414	.010	.510
88.00	-14.15	.28	.0423	.010	.446
90.00	-14.05	.28	.0432	.010	.389
92.00	-13.94	.28	.0440	.010	.337
94.00	-13.84	.28	.0449	.010	.292
96.00	-13.75	.28	.0458	.010	.253
98.00	-13.65	.28	.0467	.010	.220
100.00	-13.55	.28	.0476	.010	.191
102.00	-13.46	.28	.0485	.010	.167
104.00	-13.37	.28	.0493	.010	.146
106.00	-13.28	.28	.0502	.010	.130
108.00	-13.19	.29	.0511	.010	.116
110.00	-13.10	.29	.0519	.010	.105
112.00	-13.01	.29	.0528	.010	.097
114.00	-12.91	.29	.0537	.010	.090
116.00	-12.81	.29	.0545	.010	.084
118.00	-12.71	.29	.0553	.010	.080

120.00	-12.59	.29	.0562	.010	.077
122.00	-12.45	.29	.0570	.010	.074
124.00	-12.29	.29	.0578	.010	.072
126.00	-12.10	.29	.0585	.010	.071
128.00	-11.85	.29	.0593	.010	.069
130.00	-11.53	.29	.0600	.010	.068
132.00	-11.12	.29	.0606	.010	.067
134.00	-10.58	.30	.0612	.010	.066
136.00	-9.89	.30	.0616	.010	.065
138.00	-9.02	.30	.0620	.010	.064
140.00	-7.95	.31	.0623	.010	.064
142.00	-6.68	.31	.0625	.010	.063
144.00	-5.22	.32	.0627	.010	.063
146.00	-3.60	.32	.0627	.010	.063
148.00	-1.85	.33	.0627	.010	.062
150.00	.00	.34	.0627	.010	.062

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 57.079

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .346

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .472

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .817

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 30.64991

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.46579

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .16348

CUMULATIVE WATER OUTFLOW , CM = 16.34771

TOTAL ELAPSED TIME = 4.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-44.85	.30	.0000	.000	1.804
2.00	-43.12	.31	.0080	.000	1.763
4.00	-41.30	.31	.0044	.000	1.778
6.00	-39.47	.32	.0047	.000	1.803
8.00	-37.64	.32	.0051	.000	1.836
10.00	-35.80	.32	.0055	.000	1.874
12.00	-33.95	.33	.0060	.000	1.916
14.00	-32.09	.33	.0064	.001	1.959
16.00	-30.29	.31	.0068	.001	2.001
18.00	-29.69	.31	.0074	.002	2.040
20.00	-29.10	.32	.0080	.002	2.076
22.00	-28.52	.32	.0086	.002	2.109
24.00	-27.95	.32	.0092	.003	2.138
26.00	-27.38	.32	.0099	.003	2.163
28.00	-26.80	.32	.0105	.004	2.185
30.00	-26.22	.33	.0111	.004	2.203
32.00	-25.60	.33	.0117	.005	2.218
34.00	-24.96	.33	.0123	.005	2.228
36.00	-24.29	.33	.0129	.006	2.235
38.00	-23.56	.34	.0135	.006	2.235
40.00	-22.77	.34	.0141	.007	2.229
42.00	-21.91	.34	.0147	.007	2.198
44.00	-20.98	.35	.0152	.008	2.148
46.00	-19.46	.26	.0158	.008	2.091
48.00	-19.25	.26	.0164	.008	2.035
50.00	-19.06	.26	.0170	.008	1.977
52.00	-18.87	.26	.0177	.009	1.917
54.00	-18.68	.26	.0183	.009	1.854

56.00	-18.50	.26	.0189	.009	1.790
58.00	-18.33	.26	.0195	.009	1.723
60.00	-18.16	.26	.0202	.009	1.653
62.00	-18.00	.27	.0208	.009	1.582
64.00	-17.84	.27	.0214	.009	1.508
66.00	-17.68	.27	.0221	.009	1.432
68.00	-17.53	.27	.0227	.009	1.354
70.00	-17.39	.27	.0233	.009	1.275
72.00	-17.25	.27	.0240	.009	1.196
74.00	-17.11	.27	.0246	.009	1.116
76.00	-16.98	.27	.0252	.010	1.038
78.00	-16.85	.27	.0258	.010	.960
80.00	-16.72	.27	.0265	.010	.884
82.00	-16.60	.27	.0271	.010	.810
84.00	-16.48	.27	.0277	.010	.739
86.00	-16.36	.27	.0283	.010	.672
88.00	-16.25	.27	.0290	.010	.608
90.00	-16.14	.27	.0296	.010	.546
92.00	-16.03	.27	.0302	.010	.488
94.00	-15.92	.27	.0308	.010	.434
96.00	-15.82	.27	.0314	.010	.385
98.00	-15.71	.27	.0320	.010	.341
100.00	-15.61	.28	.0327	.010	.301
102.00	-15.51	.28	.0333	.010	.266
104.00	-15.41	.28	.0339	.010	.235
106.00	-15.31	.28	.0345	.010	.207
108.00	-15.21	.28	.0351	.010	.184
110.00	-15.11	.28	.0357	.010	.163
112.00	-15.01	.28	.0363	.010	.145
114.00	-14.90	.28	.0369	.010	.130
116.00	-14.78	.28	.0374	.010	.117
118.00	-14.64	.28	.0380	.010	.107
120.00	-14.49	.28	.0386	.010	.098
122.00	-14.31	.28	.0391	.010	.090
124.00	-14.09	.28	.0397	.010	.084
126.00	-13.81	.28	.0402	.010	.078
128.00	-13.46	.28	.0407	.010	.074
130.00	-13.02	.29	.0411	.010	.070
132.00	-12.45	.29	.0415	.010	.066
134.00	-11.74	.29	.0418	.010	.063
136.00	-10.85	.29	.0421	.010	.060
138.00	-9.77	.30	.0424	.010	.058
140.00	-8.50	.30	.0425	.010	.056
142.00	-7.06	.31	.0426	.010	.055
144.00	-5.45	.32	.0427	.010	.053
146.00	-3.72	.32	.0427	.010	.053
148.00	-1.90	.33	.0427	.010	.052
150.00	.00	.34	.0427	.010	.052

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 48.889

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .326

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .457

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .782

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 38.78701

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 1.53162

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .17527

CUMULATIVE WATER OUTFLOW , CM = 17.52757

```
WATER  BALANCE

          INPUT ,
              AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS      CYCLE, CM =  54.90002
              AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS      CYCLE, CM =  21.00000
              TOTAL WATER INPUT ,  CM                                          =    75.90002

          OUTPUT
              AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF    THIS CYCLE, CM =  43.84124
              TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE,  CM   =                =      .00000
              AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE                   =    17.52757------------------------
              TOTAL WATER OUTPUT , CM  =                                         =    61.36880                         .
                                                                                                                       .
              BALANCE = (OUTPUT - INPUT) * 100 / INPUT  =           -19.14520  PERCENT                                 .
                                                                                                                       .
                                                                                                                       .
NITROGEN  BALANCE                                                                                                      .
                                                                                                                       .
          INPUT ,                                                                                                      .
              TOTAL  NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE,        MG - N =   6.63900               .
              WASTE WATER NITROGEN  APPLIED  DURING  THIS  CYCLE      , MG - N            =     84.00000               .
              TOTAL NITROGEN INPUT ,  MG - N  =                                           =     90.63900               .
                                                                                                                       .
                                                                                                                       .
                                                                                                                       .
          OUTPUT                                                                                                       .
              TOTAL  NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N =  49.67073                 .
              TOTAL  NITROGEN UPTAKE DURING THIS CYCLE , MG - N                            =      .00000               .
              TOTAL  NITROGEN LEACHED TO THE GROUND WATER TABLE                            =     1.70690------------- .
              TOTAL NITROGEN OUTPUT ,  MG - N  =                                           =   90.16463                .
                                                                                                                       .
              BALANCE = (OUTPUT - INPUT) * 100 / INPUT  =              -.52336  PERCENT                                .
                                                                                                                       .
                                                                                                                       .
                                                                                                                       .
*****************************.......................................................................................
  *  1.706 mg N / 17.5 cm H2O  *
  *  yields 0.097 mg N / L     *
 ******************************
```

APPENDIX C: RESULTS OF SIMULATION 2.

```
*****************************************************************
*   Initial simulation number 2                                 *
*                                                               *
*   SUMMARY INPUT                                               *
*   21 CM Wastewater, 4 mg/L NO3-N, applied daily for 4 days,   *
*   output listed for 4 days.                                   *
*****************************************************************
```

```
                   I N P U T   D A T A

    INITIAL DT, HR =    .01000
    INITIAL DZ , CM=   1.00000


    TOTAL LENGTH OF SOIL PROFILE, CM = 150.00000
    SOIL DEPTH TO THE FIRST SOIL LAYER, CM =  15.00000
    SOIL DEPTH TO THE SECOND SOIL LAYER, CM =  45.00000

    SOIL WATER PARAMETERS FOR THE FIRST  LAYER :      .9600E-05      .2763E+02      .1000E+03      .1000E+01
    SOIL WATER PARAMETERS FOR THE SECOND LAYER :      .2200E-05      .3070E+02      .4000E+02      .1000E+01
    SOIL WATER PARAMETERS FOR THE THIRD  LAYER :      .2100E-05      .3887E+02      .3000E+02      .1000E+01
    FIRST LAYER  ;  BULK DENSITY =   1.60000          SATURATION =    .44000
    SECOND LAYER ;  BULK DENSITY =   1.60000          SATURATION =    .42000
    THIRD  LAYER ;  BULK DENSITY =   1.60000          SATURATION =    .34000

    FIRST LAYER:          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                         NITRIFICATION RATE COEF.,HR-1 =    .10000
                         DENITRIFICATION RATE COEF., HR-1 =    .01000
    SECOND LAYER          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                         NITRIFICATION RATE COEF.,HR-1 =    .10000
                         DENITRIFICATION RATE COEF., HR-1 =    .01000
    THIRD LAYER:          NH4-N EXCHANGEABLE COEFFICIENT, CM3/GM =    .25000
                         NITRIFICATION RATE COEF.,HR-1 =    .10000
                         DENITRIFICATION RATE COEF., HR-1 =    .01000

    SOLUTE DISPERSION COEFFICIENT, CM**2/HR =   2.50000

    MICHAELIS CONSTANT, MG/LITRE  =   1.00000

    INITIAL DISTRIBUTION OF PRESSURE HEAD,CM
   .000    .000    .000    .000
    AT THE CORRESPONDING SOIL DEPTHS OF, CM
  7.500  40.000  75.000 150.000
    INITIAL DISTRIBUTION OF NH4-N,MG/ML IN SOL
   .010    .010    .010    .010    .010    .010
    AT THE CORRESPONDING SOIL DEPTHS OF, CM
  7.500  15.000  30.500  48.000  98.000 150.000
    INITIAL DISTRIBUTION OF NO3-N,MG/ML IN SOL
   .100    .100    .100    .100    .100    .100
    AT THE CORRESPONDING SOIL DEPTHS OF, CM
  7.500  15.000  30.500  48.000  98.000 150.000
                         TOTAL ELAPSED TIME  =       .00  DAYS
```

SOIL DEPTH CM	PRESSURE HEAD	SOIL-WATER CONTENT **3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	.00	.44	.0000	.010	.100
2.00	.00	.44	.0042	.010	.100
4.00	.00	.44	.0042	.010	.100
6.00	.00	.44	.0042	.010	.100
8.00	.00	.44	.0042	.010	.100
10.00	.00	.44	.0042	.010	.100
12.00	.00	.44	.0042	.010	.100
14.00	.00	.44	.0042	.010	.100
16.00	.00	.42	1.8284	.010	.100

18.00	.00	.42	.0014	.010	.100
20.00	.00	.42	.0014	.010	.100
22.00	.00	.42	.0014	.010	.100
24.00	.00	.42	.0014	.010	.100
26.00	.00	.42	.0014	.010	.100
28.00	.00	.42	.0014	.010	.100
30.00	.00	.42	.0014	.010	.100
32.00	.00	.42	.0014	.010	.100
34.00	.00	.42	.0014	.010	.100
36.00	.00	.42	.0014	.010	.100
38.00	.00	.42	.0014	.010	.100
40.00	.00	.42	.0014	.010	.100
42.00	.00	.42	.0014	.010	.100
44.00	.00	.42	.0014	.010	.100
46.00	.00	.34	.8754	.010	.100
48.00	.00	.34	.0016	.010	.100
50.00	.00	.34	.0016	.010	.100
52.00	.00	.34	.0016	.010	.100
54.00	.00	.34	.0016	.010	.100
56.00	.00	.34	.0016	.010	.100
58.00	.00	.34	.0016	.010	.100
60.00	.00	.34	.0016	.010	.100
62.00	.00	.34	.0016	.010	.100
64.00	.00	.34	.0016	.010	.100
66.00	.00	.34	.0016	.010	.100
68.00	.00	.34	.0016	.010	.100
70.00	.00	.34	.0016	.010	.100
72.00	.00	.34	.0016	.010	.100
74.00	.00	.34	.0016	.010	.100
76.00	.00	.34	.0016	.010	.100
78.00	.00	.34	.0016	.010	.100
80.00	.00	.34	.0016	.010	.100
82.00	.00	.34	.0016	.010	.100
84.00	.00	.34	.0016	.010	.100
86.00	.00	.34	.0016	.010	.100
88.00	.00	.34	.0016	.010	.100
90.00	.00	.34	.0016	.010	.100
92.00	.00	.34	.0016	.010	.100
94.00	.00	.34	.0016	.010	.100
96.00	.00	.34	.0016	.010	.100
98.00	.00	.34	.0016	.010	.100
100.00	.00	.34	.0016	.010	.100
102.00	.00	.34	.0016	.010	.100
104.00	.00	.34	.0016	.010	.100
106.00	.00	.34	.0016	.010	.100
108.00	.00	.34	.0016	.010	.100
110.00	.00	.34	.0016	.010	.100
112.00	.00	.34	.0016	.010	.100
114.00	.00	.34	.0016	.010	.100
116.00	.00	.34	.0016	.010	.100
118.00	.00	.34	.0016	.010	.100
120.00	.00	.34	.0016	.010	.100
122.00	.00	.34	.0016	.010	.100
124.00	.00	.34	.0016	.010	.100
126.00	.00	.34	.0016	.010	.100
128.00	.00	.34	.0016	.010	.100
130.00	.00	.34	.0016	.010	.100
132.00	.00	.34	.0016	.010	.100
134.00	.00	.34	.0016	.010	.100
136.00	.00	.34	.0016	.010	.100
138.00	.00	.34	.0016	.010	.100
140.00	.00	.34	.0016	.010	.100
142.00	.00	.34	.0016	.010	.100
144.00	.00	.34	.0016	.010	.100
146.00	.00	.34	.0016	.010	.100
148.00	.00	.34	.0016	.010	.100
150.00	.00	.34	.0016	.010	.100

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 5.490

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .549

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .600

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = 1.149

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = .00000

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

THIS IS CYCLE NUMBER = 1

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 1.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD	SOIL-WATER CONTENT **3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-4.84	.42	.8750	.000	3.989
2.00	-4.50	.42	.8829	.000	3.951
4.00	-4.09	.42	.8829	.000	3.914
6.00	-3.61	.42	.8829	.000	3.876
8.00	-3.04	.43	.8829	.000	3.839
10.00	-2.37	.43	.8829	.000	3.802
12.00	-1.59	.43	.8829	.000	3.765
14.00	-.70	.44	.8829	.000	3.728
16.00	.08	.42	.8829	.000	3.693
18.00	.07	.42	.8829	.000	3.658
20.00	.07	.42	.8829	.002	3.623
22.00	.05	.42	.8829	.003	3.588
24.00	.04	.42	.8829	.004	3.553
26.00	.03	.42	.8829	.005	3.517
28.00	.01	.42	.8829	.006	3.478
30.00	-.00	.42	.8829	.008	3.434
32.00	-.02	.42	.8829	.008	3.381
34.00	-.06	.42	.8829	.009	3.315
36.00	-.11	.42	.8829	.009	3.228
38.00	-.18	.42	.8829	.010	3.114
40.00	-.30	.42	.8829	.010	2.966
42.00	-.48	.42	.8829	.010	2.780
44.00	-.76	.42	.8829	.010	2.558
46.00	-.90	.34	.8829	.010	2.342
48.00	-.90	.34	.8829	.010	2.116
50.00	-.90	.34	.8829	.010	1.875

52.00	-.90	.34	.8829	.010	1.627
54.00	-.90	.34	.8829	.010	1.379
56.00	-.90	.34	.8829	.010	1.141
58.00	-.90	.34	.8829	.010	.922
60.00	-.90	.34	.8829	.010	.728
62.00	-.90	.34	.8829	.010	.562
64.00	-.89	.34	.8829	.010	.427
66.00	-.88	.34	.8829	.010	.321
68.00	-.87	.34	.8829	.010	.241
70.00	-.84	.34	.8829	.010	.184
72.00	-.79	.34	.8829	.010	.144
74.00	-.71	.34	.8829	.010	.118
76.00	-.58	.34	.8829	.010	.102
78.00	-.36	.34	.8829	.010	.093
80.00	.00	.34	.8829	.010	.090
82.00	.00	.34	1.1528	.010	.100
84.00	.00	.34	.0016	.010	.100
86.00	.00	.34	.0016	.010	.100
88.00	.00	.34	.0016	.010	.100
90.00	.00	.34	.0016	.010	.100
92.00	.00	.34	.0016	.010	.100
94.00	.00	.34	.0016	.010	.100
96.00	.00	.34	.0016	.010	.100
98.00	.00	.34	.0016	.010	.100
100.00	.00	.34	.0016	.010	.100
102.00	.00	.34	.0016	.010	.100
104.00	.00	.34	.0016	.010	.100
106.00	.00	.34	.0016	.010	.100
108.00	.00	.34	.0016	.010	.100
110.00	.00	.34	.0016	.010	.100
112.00	.00	.34	.0016	.010	.100
114.00	.00	.34	.0016	.010	.100
116.00	.00	.34	.0016	.010	.100
118.00	.00	.34	.0016	.010	.100
120.00	.00	.34	.0016	.010	.100
122.00	.00	.34	.0016	.010	.100
124.00	.00	.34	.0016	.010	.100
126.00	.00	.34	.0016	.010	.100
128.00	.00	.34	.0016	.010	.100
130.00	.00	.34	.0016	.010	.100
132.00	.00	.34	.0016	.010	.100
134.00	.00	.34	.0016	.010	.100
136.00	.00	.34	.0016	.010	.100
138.00	.00	.34	.0016	.010	.100
140.00	.00	.34	.0016	.010	.100
142.00	.00	.34	.0016	.010	.100
144.00	.00	.34	.0016	.010	.100
146.00	.00	.34	.0016	.010	.100
148.00	.00	.34	.0016	.010	.100
150.00	.00	.34	.0016	.010	.100

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 78.575

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .436

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .497

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .933

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 9.94938

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .00000

CUMULATIVE WATER OUTFLOW , CM = .00000

W A T E R   B A L A N C E

I N P U T ,

AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS CYCLE, CM = 54.90002
AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS CYCLE, CM = 21.00000
TOTAL WATER INPUT , CM = 75.90002

O U T P U T

AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THIS CYCLE, CM = 48.59818
TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = = .00000
AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE = 12.94017
TOTAL WATER OUTPUT , CM = = 61.53835

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -18.92183 PERCENT

N I T R O G E N   B A L A N C E

I N P U T ,

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE, MG - N = 6.63900
WASTE WATER NITROGEN APPLIED DURING THIS CYCLE , MG - N = 84.00000
TOTAL NITROGEN INPUT , MG - N = = 90.63900

O U T P U T

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 79.50768
TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N = .00000
TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE = 1.34106
TOTAL NITROGEN OUTPUT , MG - N = = 98.38721

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = 8.54843 PERCENT
THIS IS CYCLE NUMBER = 2

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 2.50 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-4.84	.42	.8750	.000	3.989
2.00	-4.50	.42	.8829	.000	3.951
4.00	-4.09	.42	.8829	.000	3.914
6.00	-3.61	.42	.8829	.000	3.876
8.00	-3.04	.43	.8829	.000	3.839

10.00	-2.37	.43	.8829	.000	3.802
12.00	-1.59	.43	.8829	.000	3.765
14.00	-.70	.44	.8829	.000	3.728
16.00	.08	.42	.8829	.000	3.693
18.00	.07	.42	.8829	.000	3.658
20.00	.07	.42	.8829	.000	3.623
22.00	.05	.42	.8829	.000	3.589
24.00	.04	.42	.8829	.000	3.555
26.00	.03	.42	.8829	.000	3.521
28.00	.01	.42	.8829	.000	3.487
30.00	-.00	.42	.8829	.000	3.453
32.00	-.02	.42	.8829	.000	3.419
34.00	-.06	.42	.8829	.000	3.384
36.00	-.11	.42	.8829	.000	3.347
38.00	-.18	.42	.8829	.000	3.308
40.00	-.30	.42	.8829	.001	3.267
42.00	-.48	.42	.8829	.002	3.223
44.00	-.76	.42	.8829	.002	3.176
46.00	-.90	.34	.8829	.003	3.135
48.00	-.90	.34	.8829	.003	3.095
50.00	-.90	.34	.8829	.004	3.053
52.00	-.90	.34	.8829	.005	3.012
54.00	-.90	.34	.8829	.006	2.971
56.00	-.90	.34	.8829	.006	2.930
58.00	-.90	.34	.8829	.007	2.891
60.00	-.90	.34	.8829	.008	2.854
62.00	-.90	.34	.8829	.008	2.818
64.00	-.90	.34	.8829	.009	2.783
66.00	-.90	.34	.8829	.009	2.749
68.00	-.90	.34	.8829	.009	2.716
70.00	-.90	.34	.8829	.010	2.684
72.00	-.90	.34	.8829	.010	2.651
74.00	-.90	.34	.8829	.010	2.619
76.00	-.90	.34	.8829	.010	2.586
78.00	-.90	.34	.8829	.010	2.553
80.00	-.90	.34	.8829	.010	2.519
82.00	-.90	.34	.8829	.010	2.481
84.00	-.90	.34	.8829	.010	2.435
86.00	-.90	.34	.8829	.010	2.353
88.00	-.90	.34	.8829	.010	2.173
90.00	-.90	.34	.8829	.010	1.835
92.00	-.90	.34	.8829	.010	1.367
94.00	-.90	.34	.8829	.010	.892
96.00	-.90	.34	.8829	.010	.526
98.00	-.90	.34	.8829	.010	.302
100.00	-.90	.34	.8829	.010	.188
102.00	-.90	.34	.8829	.010	.135
104.00	-.90	.34	.8829	.010	.111
106.00	-.90	.34	.8829	.010	.099
108.00	-.90	.34	.8829	.010	.092
110.00	-.90	.34	.8829	.010	.088
112.00	-.90	.34	.8829	.010	.086
114.00	-.90	.34	.8829	.010	.085
116.00	-.90	.34	.8829	.010	.085
118.00	-.90	.34	.8829	.010	.085
120.00	-.90	.34	.8829	.010	.085
122.00	-.90	.34	.8829	.010	.085
124.00	-.90	.34	.8829	.010	.085
126.00	-.90	.34	.8829	.010	.085
128.00	-.90	.34	.8829	.010	.085
130.00	-.90	.34	.8829	.010	.085
132.00	-.90	.34	.8829	.010	.085
134.00	-.89	.34	.8829	.010	.085
136.00	-.88	.34	.8829	.010	.085
138.00	-.87	.34	.8829	.010	.085
140.00	-.84	.34	.8829	.010	.085
142.00	-.79	.34	.8829	.010	.085
144.00	-.71	.34	.8829	.010	.085
146.00	-.58	.34	.8829	.010	.085
148.00	-.36	.34	.8829	.010	.085
150.00	.00	.34	.8829	.010	.085

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TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS =   113.348

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS =      .330

TOTAL NH-4 NITROGEN IN  EXCHANGEABLE PHASE , MICROGRAMS =      .391

TOTAL NH-4 NITROGEN IN  THE SOIL  PROFILE  , MICROGRAMS =      .720


CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 37.85138


CUMULATIVE  NITRATE  NITROGEN UPTAKE,  MICROGRAMS =      .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE,  MICROGRAMS =      .000


CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE,   MG - N =  1.21165

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE,  MG - N =     .12940

CUMULATIVE WATER OUTFLOW , CM =  12.94017


W A T E R   B A L A N C E

     I N P U T ,
        AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS      CYCLE, CM =  48.59818
        AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS      CYCLE, CM =  21.00000
        TOTAL WATER INPUT ,  CM                                            =    69.59818

     O U T P U T
        AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF     THIS CYCLE, CM =  48.59818
        TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE,  CM    =               =      .00000
        AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE                   =    12.94016
        TOTAL WATER OUTPUT , CM  =                                         =    61.53834

        BALANCE = (OUTPUT - INPUT) * 100 / INPUT  =          -11.58052  PERCENT


N I T R O G E N   B A L A N C E

     I N P U T ,
        TOTAL  NITROGEN PRESENT IN THE SOIL PROFILE FROM      PREVIOUS CYCLE,  MG - N =  79.50768
        WASTE WATER NITROGEN  APPLIED  DURING  THIS  CYCLE     , MG - N            =    84.00000
        TOTAL NITROGEN INPUT ,  MG - N  =                                         = 163.50770


     O U T P U T
        TOTAL  NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 114.06890
        TOTAL  NITROGEN UPTAKE DURING THIS CYCLE , MG - N                          =      .00000
        TOTAL  NITROGEN LEACHED TO THE GROUND WATER TABLE                          =     1.15399
        TOTAL NITROGEN OUTPUT ,  MG - N  =                                         = 164.58610


        BALANCE = (OUTPUT - INPUT) * 100 / INPUT  =              .65957  PERCENT
             THIS IS CYCLE NUMBER  =  3


AMOUNT OF   WASTE WATER APPLIED , CM =  21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS =  1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS    =  1.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE,   DAYS  =  1.00000


CONCENTRATION OF APPLIED NH4-N , MG/LITRE =    .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE =   4.00000
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NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 4.00 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-4.84	.42	.8750	.000	3.989
2.00	-4.50	.42	.8829	.000	3.951
4.00	-4.09	.42	.8829	.000	3.914
6.00	-3.61	.42	.8829	.000	3.876
8.00	-3.04	.43	.8829	.000	3.839
10.00	-2.37	.43	.8829	.000	3.802
12.00	-1.59	.43	.8829	.000	3.765
14.00	-.70	.44	.8829	.000	3.728
16.00	.08	.42	.8829	.000	3.693
18.00	.07	.42	.8829	.000	3.658
20.00	.07	.42	.8829	.000	3.623
22.00	.05	.42	.8829	.000	3.589
24.00	.04	.42	.8829	.000	3.555
26.00	.03	.42	.8829	.000	3.521
28.00	.01	.42	.8829	.000	3.487
30.00	-.00	.42	.8829	.000	3.453
32.00	-.02	.42	.8829	.000	3.419
34.00	-.06	.42	.8829	.000	3.384
36.00	-.11	.42	.8829	.000	3.347
38.00	-.18	.42	.8829	.000	3.308
40.00	-.30	.42	.8829	.000	3.267
42.00	-.48	.42	.8829	.000	3.223
44.00	-.76	.42	.8829	.000	3.176
46.00	-.90	.34	.8829	.000	3.135
48.00	-.90	.34	.8829	.000	3.095
50.00	-.90	.34	.8829	.000	3.054
52.00	-.90	.34	.8829	.000	3.012
54.00	-.90	.34	.8829	.000	2.971
56.00	-.90	.34	.8829	.000	2.931
58.00	-.90	.34	.8829	.000	2.892
60.00	-.90	.34	.8829	.000	2.855
62.00	-.90	.34	.8829	.000	2.819
64.00	-.90	.34	.8829	.001	2.785
66.00	-.90	.34	.8829	.001	2.752
68.00	-.90	.34	.8829	.002	2.720
70.00	-.90	.34	.8829	.002	2.690
72.00	-.90	.34	.8829	.003	2.660
74.00	-.90	.34	.8829	.004	2.631
76.00	-.90	.34	.8829	.005	2.602
78.00	-.90	.34	.8829	.006	2.575
80.00	-.90	.34	.8829	.007	2.548
82.00	-.90	.34	.8829	.008	2.522
84.00	-.90	.34	.8829	.009	2.496
86.00	-.90	.34	.8829	.009	2.471
88.00	-.90	.34	.8829	.009	2.446
90.00	-.90	.34	.8829	.010	2.419
92.00	-.90	.34	.8829	.010	2.389
94.00	-.90	.34	.8829	.010	2.357
96.00	-.90	.34	.8829	.010	2.323
98.00	-.90	.34	.8829	.010	2.289
100.00	-.90	.34	.8829	.010	2.255
102.00	-.90	.34	.8829	.010	2.223
104.00	-.90	.34	.8829	.010	2.190
106.00	-.90	.34	.8829	.010	2.157
108.00	-.90	.34	.8829	.010	2.121
110.00	-.90	.34	.8829	.010	2.080
112.00	-.90	.34	.8829	.010	2.031
114.00	-.90	.34	.8829	.010	1.970
116.00	-.90	.34	.8829	.010	1.894

118.00	-.90	.34	.8829	.010	1.800
120.00	-.90	.34	.8829	.010	1.686
122.00	-.90	.34	.8829	.010	1.552
124.00	-.90	.34	.8829	.010	1.401
126.00	-.90	.34	.8829	.010	1.237
128.00	-.90	.34	.8829	.010	1.066
130.00	-.90	.34	.8829	.010	.897
132.00	-.90	.34	.8829	.010	.736
134.00	-.89	.34	.8829	.010	.590
136.00	-.88	.34	.8829	.010	.463
138.00	-.87	.34	.8829	.010	.357
140.00	-.84	.34	.8829	.010	.273
142.00	-.79	.34	.8829	.010	.209
144.00	-.71	.34	.8829	.010	.161
146.00	-.58	.34	.8829	.010	.128
148.00	-.36	.34	.8829	.010	.106
150.00	.00	.34	.8829	.010	.097

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 138.038

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .250

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .297

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .546

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS = 72.36671

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 2.23624

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .25880

CUMULATIVE WATER OUTFLOW , CM = 25.88033

W A T E R   B A L A N C E

I N P U T ,

AMOUNT OF WATER IN THE SOIL PROFILE FROM PREVIOUS CYCLE, CM = 48.59818
AMOUNT OF WASTE WATER APPLIED OR RAINFALL IN THIS CYCLE, CM = 21.00000
TOTAL WATER INPUT , CM = 69.59818

O U T P U T

AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THIS CYCLE, CM = 48.59818
TOTAL EVAPOTRANSPIRATION DURING THIS CYCLE, CM = = .00000
AMOUNT OF GROUND WATER OUTFLOW DURING THIS CYCLE = 12.94016
TOTAL WATER OUTPUT , CM = = 61.53834

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = -11.58053 PERCENT

N I T R O G E N   B A L A N C E

I N P U T ,

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE FROM PREVIOUS CYCLE, MG - N = 114.06890
WASTE WATER NITROGEN APPLIED DURING THIS CYCLE , MG - N = 84.00000
TOTAL NITROGEN INPUT , MG - N = = 198.06890

O U T P U T

TOTAL NITROGEN PRESENT IN THE SOIL PROFILE AT THE END OF THIS CYCLE, MG - N = 138.58430
TOTAL NITROGEN UPTAKE DURING THIS CYCLE , MG - N = .00000
TOTAL NITROGEN LEACHED TO THE GROUND WATER TABLE = 6.47231
TOTAL NITROGEN OUTPUT , MG - N = = 231.64220

BALANCE = (OUTPUT - INPUT) * 100 / INPUT = 16.95035 PERCENT
THIS IS CYCLE NUMBER = 4

AMOUNT OF WASTE WATER APPLIED , CM = 21.00000
INFILTRATION TIME, I.E. DURATION OF WASTE WATER APPLICATION, DAYS = 1.00000
SCHEDULE OF WASTE WATER APPLICATION, I.E. CYCLE DURATION ,DAYS = 4.00000

TIME AT WHICH OUTPUT DATA IS REQUESTED IN THIS CYCLE, DAYS = 1.00000

CONCENTRATION OF APPLIED NH4-N , MG/LITRE = .00000
CONCENTRATION OF APPLIED NO3-N , MG/LITRE = 4.00000

NITROGEN UPTAKE RATE, MICROGRAM-N/CM OF ROOT LENGTH PER DAY = .00000

EVAPOTRANSPIRATION RATE, CM/DAY = .00000

TOTAL ELAPSED TIME = 5.50 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-4.84	.42	.8750	.000	3.989
2.00	-4.50	.42	.8829	.000	3.951
4.00	-4.09	.42	.8829	.000	3.914
6.00	-3.61	.42	.8829	.000	3.876
8.00	-3.04	.43	.8829	.000	3.839
10.00	-2.37	.43	.8829	.000	3.802
12.00	-1.59	.43	.8829	.000	3.765
14.00	-.70	.44	.8829	.000	3.728
16.00	.08	.42	.8829	.000	3.693
18.00	.07	.42	.8829	.000	3.658
20.00	.07	.42	.8829	.000	3.623
22.00	.05	.42	.8829	.000	3.589
24.00	.04	.42	.8829	.000	3.555
26.00	.03	.42	.8829	.000	3.521
28.00	.01	.42	.8829	.000	3.487
30.00	-.00	.42	.8829	.000	3.453
32.00	-.02	.42	.8829	.000	3.419
34.00	-.06	.42	.8829	.000	3.384
36.00	-.11	.42	.8829	.000	3.347
38.00	-.18	.42	.8829	.000	3.308
40.00	-.30	.42	.8829	.000	3.267
42.00	-.48	.42	.8829	.000	3.223
44.00	-.76	.42	.8829	.000	3.176
46.00	-.90	.34	.8829	.000	3.135
48.00	-.90	.34	.8829	.000	3.095
50.00	-.90	.34	.8829	.000	3.054
52.00	-.90	.34	.8829	.000	3.012
54.00	-.90	.34	.8829	.000	2.971
56.00	-.90	.34	.8829	.000	2.931
58.00	-.90	.34	.8829	.000	2.892
60.00	-.90	.34	.8829	.000	2.855
62.00	-.90	.34	.8829	.000	2.819
64.00	-.90	.34	.8829	.000	2.785
66.00	-.90	.34	.8829	.000	2.752
68.00	-.90	.34	.8829	.000	2.720
70.00	-.90	.34	.8829	.000	2.690

72.00	-.90	.34	.8829	.000	2.660
74.00	-.90	.34	.8829	.000	2.631
76.00	-.90	.34	.8829	.000	2.602
78.00	-.90	.34	.8829	.000	2.575
80.00	-.90	.34	.8829	.000	2.548
82.00	-.90	.34	.8829	.001	2.522
84.00	-.90	.34	.8829	.002	2.496
86.00	-.90	.34	.8829	.002	2.471
88.00	-.90	.34	.8829	.003	2.446
90.00	-.90	.34	.8829	.004	2.419
92.00	-.90	.34	.8829	.005	2.390
94.00	-.90	.34	.8829	.005	2.358
96.00	-.90	.34	.8829	.006	2.325
98.00	-.90	.34	.8829	.007	2.292
100.00	-.90	.34	.8829	.008	2.260
102.00	-.90	.34	.8829	.008	2.230
104.00	-.90	.34	.8829	.009	2.202
106.00	-.90	.34	.8829	.009	2.175
108.00	-.90	.34	.8829	.009	2.150
110.00	-.90	.34	.8829	.010	2.125
112.00	-.90	.34	.8829	.010	2.102
114.00	-.90	.34	.8829	.010	2.079
116.00	-.90	.34	.8829	.010	2.056
118.00	-.90	.34	.8829	.010	2.033
120.00	-.90	.34	.8829	.010	2.011
122.00	-.90	.34	.8829	.010	1.988
124.00	-.90	.34	.8829	.010	1.965
126.00	-.90	.34	.8829	.010	1.941
128.00	-.90	.34	.8829	.010	1.917
130.00	-.90	.34	.8829	.010	1.891
132.00	-.90	.34	.8829	.010	1.865
134.00	-.89	.34	.8829	.010	1.838
136.00	-.88	.34	.8829	.010	1.809
138.00	-.87	.34	.8829	.010	1.778
140.00	-.84	.34	.8829	.010	1.745
142.00	-.79	.34	.8829	.010	1.707
144.00	-.71	.34	.8829	.010	1.665
146.00	-.58	.34	.8829	.010	1.617
148.00	-.36	.34	.8829	.010	1.562
150.00	.00	.34	.8829	.010	1.530

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 150.058

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .192

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .228

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .420

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =111.19380

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 8.57915

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .38820

CUMULATIVE WATER OUTFLOW , CM = 38.82050

TOTAL ELAPSED TIME = 6.50 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML

.00	-38.36	.32	.0000	.000	3.151
2.00	-36.41	.32	.0017	.000	3.151
4.00	-34.48	.33	.0024	.000	3.165
6.00	-32.58	.33	.0039	.000	3.184
8.00	-30.70	.34	.0055	.000	3.207
10.00	-28.84	.34	.0071	.000	3.232
12.00	-26.98	.35	.0088	.000	3.257
14.00	-25.12	.35	.0104	.000	3.280
16.00	-23.34	.34	.0122	.000	3.291
18.00	-22.60	.34	.0143	.000	3.274
20.00	-21.93	.34	.0164	.000	3.240
22.00	-21.31	.34	.0186	.000	3.196
24.00	-20.73	.35	.0207	.000	3.149
26.00	-20.18	.35	.0227	.000	3.100
28.00	-19.66	.35	.0248	.000	3.052
30.00	-19.15	.35	.0268	.000	3.005
32.00	-18.65	.35	.0287	.000	2.959
34.00	-18.14	.35	.0306	.000	2.916
36.00	-17.62	.36	.0325	.000	2.874
38.00	-17.08	.36	.0343	.000	2.835
40.00	-16.49	.36	.0361	.000	2.799
42.00	-15.86	.36	.0378	.000	2.768
44.00	-15.16	.37	.0394	.000	2.744
46.00	-13.81	.28	.0409	.000	2.732
48.00	-13.62	.28	.0426	.000	2.722
50.00	-13.44	.28	.0443	.000	2.705
52.00	-13.26	.28	.0460	.000	2.684
54.00	-13.10	.29	.0477	.000	2.659
56.00	-12.94	.29	.0494	.000	2.631
58.00	-12.78	.29	.0510	.000	2.601
60.00	-12.64	.29	.0527	.000	2.570
62.00	-12.49	.29	.0544	.000	2.538
64.00	-12.35	.29	.0560	.000	2.505
66.00	-12.22	.29	.0576	.000	2.473
68.00	-12.09	.29	.0593	.000	2.441
70.00	-11.97	.29	.0609	.000	2.409
72.00	-11.85	.29	.0625	.000	2.378
74.00	-11.73	.29	.0641	.000	2.348
76.00	-11.61	.29	.0657	.000	2.318
78.00	-11.50	.29	.0673	.000	2.290
80.00	-11.39	.29	.0689	.000	2.262
82.00	-11.29	.29	.0705	.000	2.234
84.00	-11.19	.29	.0720	.000	2.208
86.00	-11.09	.29	.0736	.001	2.182
88.00	-10.99	.29	.0752	.001	2.157
90.00	-10.90	.29	.0767	.002	2.133
92.00	-10.80	.29	.0783	.002	2.109
94.00	-10.71	.30	.0798	.003	2.086
96.00	-10.63	.30	.0814	.003	2.063
98.00	-10.54	.30	.0829	.004	2.041
100.00	-10.45	.30	.0844	.005	2.019
102.00	-10.37	.30	.0860	.005	1.997
104.00	-10.29	.30	.0875	.006	1.975
106.00	-10.21	.30	.0890	.007	1.953
108.00	-10.13	.30	.0905	.007	1.931
110.00	-10.05	.30	.0920	.008	1.909
112.00	-9.98	.30	.0935	.008	1.887
114.00	-9.90	.30	.0950	.009	1.865
116.00	-9.82	.30	.0965	.009	1.844
118.00	-9.74	.30	.0980	.009	1.822
120.00	-9.66	.30	.0995	.009	1.800
122.00	-9.57	.30	.1010	.010	1.779
124.00	-9.47	.30	.1024	.010	1.758
126.00	-9.35	.30	.1038	.010	1.737
128.00	-9.21	.30	.1052	.010	1.717
130.00	-9.04	.30	.1066	.010	1.696
132.00	-8.81	.30	.1079	.010	1.676
134.00	-8.50	.30	.1092	.010	1.656
136.00	-8.08	.31	.1103	.010	1.637
138.00	-7.53	.31	.1114	.010	1.619
140.00	-6.79	.31	.1123	.010	1.602
142.00	-5.85	.32	.1130	.010	1.586

144.00	-4.69	.32	.1136	.010	1.572
146.00	-3.30	.33	.1139	.010	1.560
148.00	-1.73	.33	.1142	.010	1.553
150.00	.00	.34	.1143	.010	1.551

TOTAL NO-3 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = 112.507

TOTAL NH-4 NITROGEN IN SOIL SOLUTION PHASE , MICROGRAMS = .149

TOTAL NH-4 NITROGEN IN EXCHANGEABLE PHASE , MICROGRAMS = .196

TOTAL NH-4 NITROGEN IN THE SOIL PROFILE , MICROGRAMS = .345

CUMULATIVE NITROGEN DENITRIFIED, MICROGRAMS =136.36470

CUMULATIVE NITRATE NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE AMMONIUM NITROGEN UPTAKE, MICROGRAMS = .000

CUMULATIVE NO3-N LEACHED TO THE GROUND WATER TABLE, MG - N = 32.99165

CUMULATIVE NH4-N LEACHED TO THE GROUND WATER TABLE, MG - N = .53334

CUMULATIVE WATER OUTFLOW , CM = 53.33479

TOTAL ELAPSED TIME = 7.50 DAYS

SOIL DEPTH CM	PRESSURE HEAD CM	SOIL-WATER CONTENT CM**3/CM**3	WATER FLOW VELOCITY CM/HR	AMMONIUM CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N/ML	NITRATE CONCENTRATION IN SOIL SOLUTION MICROGRAMS-N /ML
.00	-42.62	.31	.0000	.000	2.415
2.00	-40.86	.31	.0079	.000	2.374
4.00	-39.02	.32	.0045	.000	2.392
6.00	-37.18	.32	.0051	.000	2.421
8.00	-35.34	.33	.0056	.000	2.457
10.00	-33.50	.33	.0062	.000	2.498
12.00	-31.64	.33	.0068	.000	2.542
14.00	-29.79	.34	.0074	.000	2.585
16.00	-27.99	.32	.0081	.000	2.625
18.00	-27.30	.32	.0090	.000	2.660
20.00	-26.64	.32	.0099	.000	2.689
22.00	-26.01	.33	.0109	.000	2.714
24.00	-25.39	.33	.0119	.000	2.735
26.00	-24.79	.33	.0129	.000	2.753
28.00	-24.21	.33	.0140	.000	2.768
30.00	-23.62	.34	.0150	.000	2.778
32.00	-23.03	.34	.0160	.000	2.786
34.00	-22.42	.34	.0171	.000	2.766
36.00	-21.78	.34	.0181	.000	2.732
38.00	-21.11	.34	.0190	.000	2.691
40.00	-20.38	.35	.0200	.000	2.649
42.00	-19.60	.35	.0209	.000	2.609
44.00	-18.74	.35	.0218	.000	2.574
46.00	-17.27	.27	.0226	.000	2.553
48.00	-17.06	.27	.0236	.000	2.543
50.00	-16.86	.27	.0246	.000	2.536
52.00	-16.67	.27	.0256	.000	2.528
54.00	-16.49	.27	.0265	.000	2.519
56.00	-16.31	.27	.0275	.000	2.511
58.00	-16.14	.27	.0284	.000	2.493
60.00	-15.98	.27	.0294	.000	2.467
62.00	-15.82	.27	.0303	.000	2.437
64.00	-15.66	.27	.0313	.000	2.405
66.00	-15.52	.28	.0322	.000	2.372
68.00	-15.37	.28	.0331	.000	2.338
70.00	-15.23	.28	.0341	.000	2.303

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13. ABSTRACT (*Maximum 200 words*)

The model WASTEN was used to compare several nitrogen input scenarios and to predict the levels of nitrate in groundwater for a proposed wastewater treatment facility at Fort Dix, New Jersey. The primary variables tested were input concentration of NO_3-N (nitrate nitrogen) and NH_4-N (ammonium nitrogen) and long-term application of wastewater. Two NO_3-N loading rates, 4 and 10 mg NO_3-N/L, were tested for 168-day simulations. The system's response was estimated from the NO_3-N concentration in water draining below 150 cm. For both input NO_3-N concentrations, the predicted NO_3-N concentrations in the leachate below 150 cm were less than 2 mg NO_3-N/L. The initial NO_3-N in the soil profile represented typical background levels for this site. The final NO_3-N in the soil profile was affected by both denitrification and leaching. The initial NH_4-N in the simulated soil profile was equal to the extractable NH_4-N from soil samples taken at the Fort Dix site. Because a portion of the extractable NH_4-N exists as exchangeable rather than solution NH_4-N, the soil profile values for the solution NH_4-N used in the simulation were greater than actual soil solution values would be. Moreover, by adjusting model coefficients, all the initial NH_4-N was forced to leach in the model simulations rather than be subjected to nitrification, denitrification, immobilization or plant uptake. Due to the retardation effects on NH_4-N mobility caused by soil-ion sorption, the NH_4-N leaching was distributed over an extended time rather than moving rapidly below the unsaturated zone. With these assumptions, the WASTEN model predicted that the NO_3-N at

14. SUBJECT TERMS		15. NUMBER OF PAGES
Groundwater	Wastewater modeling	40
Nitrogen	Wastewater treatment	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
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13. ABSTRACT (cont'd.)

150 cm would be less than 1 mg NO_3-N/L if the applied NO_3-N was 4 mg NO_3-N/L, and less than 2 mg NO_3-N/L if 10 mg NO_3-N/L was applied. The predicted NO_4^+ concentration in the leachate was very low, even when an initial, uniform saturation of 5.0 mg NH_4-N/L in the soil profile was assumed. In field situations there would be little, if any, NO_4^+ present following tertiary treatment of wastewater. Based on these calculations, the predicted concentration of NH_4-N in the applied effluent would remain within regulatory requirements.